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Editorials, Commentaries, and Reviews To Note

Legionnaires Disease Associated with a Whirlpool Spa Display—Virginia, September–October 1996—From the Centers for Disease Control and Prevention. JAMA 1997;277(9):705.

Effect of Smoking on Micronucleated Epithelial Cells in Smears from the Uterine Cervix—Lehucher-Michel MP, Favre-Eloff G, Devictor B, Duffaud F, Botta A. Carcinogenesis 1997;18(4):749.

Pertussis Vaccination: Use of Acellular Pertussis Vaccines among Infants and Young Children. Recommendations of the Advisory Committee on Immunization Practices (ACIP)—MMWR Morb Mortal Wkly Rep 1997 Mar 28:46(Rr-7):1.

Attitude Towards Smoking and Oral Cancer Prevention among Northern Italian Dentists—Lodi G, Bez C, Rimondini L, Zuppiroli A, Sardella A, Carrassi A. Oral Oncol 1997;33(2):100.

National Immunization Days: State of the Art—Birmingham ME, Aylward RB, Cochi SL, Hull HF. J Infect Dis 1997:175 Suppl 1:S183.

Asthma and Its Pathogenesis—Clinical and Scientific Aspects. Abstracts of the 15th Summer Meeting of the British Association for Lung Research. Southampton, United Kingdom, 19-20 September 1996. Respir Med 1997 ;91(1):A1-A46.

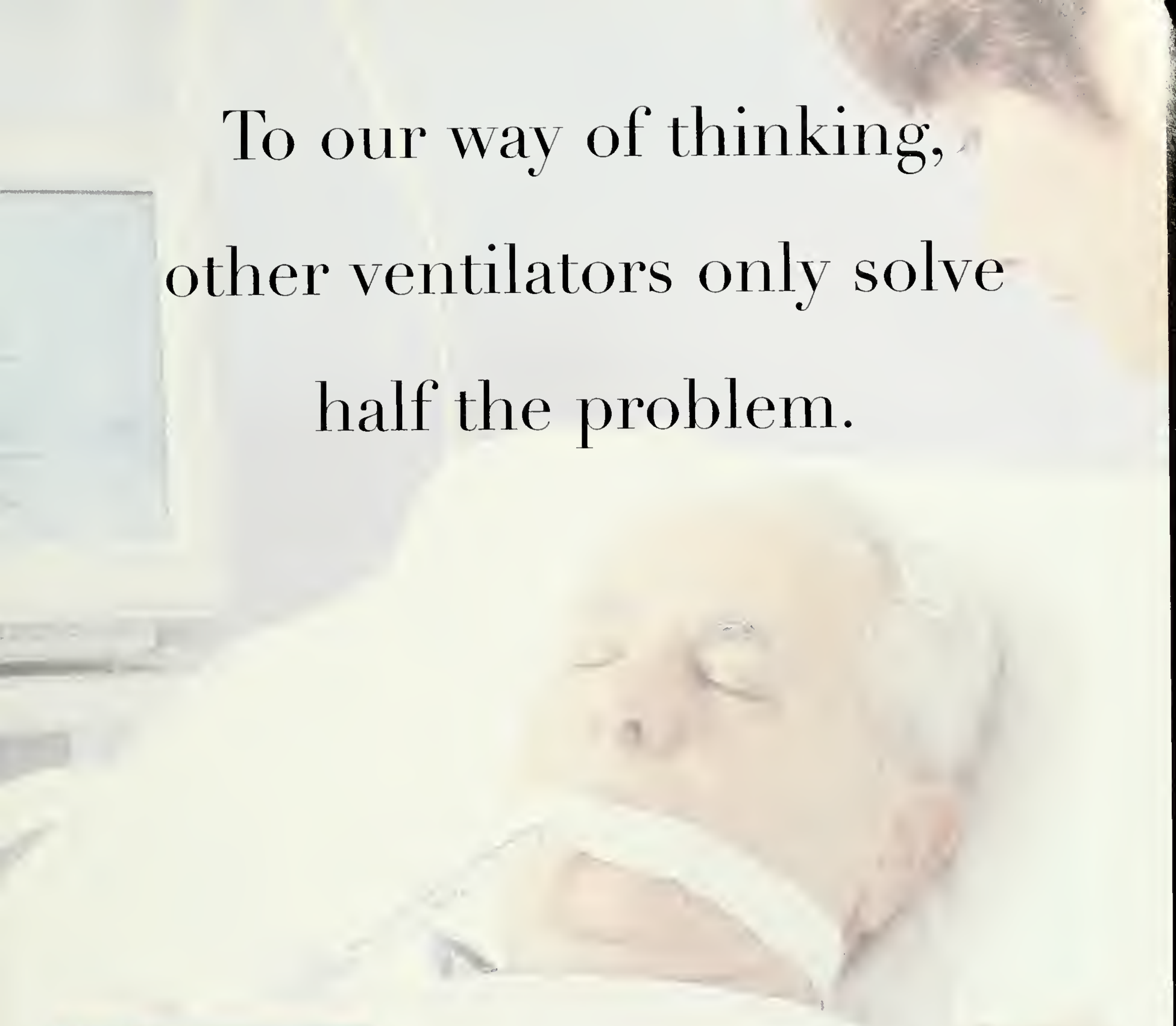
Comparing a Computer-Based Childhood Vaccination Registry with Parental Vaccination Cards: A Population-Based Study of Delaware Children—Ortega AN, Andrews SF, Katz SH, Dowshen SA, Curtice WS, Cannon ME, et al. Clin Pediatr (Phila) 1997;36(4):217

Emergency Treatment of Acute Asthma with Albuterol Metered-Dose Inhaler Plus Holding Chamber: How Often Should Treatments Be Administered?—JP Karpel, TK Aldrich, DJ Prezant, K Guguchev, A Gaitan-Salas, R Pathiparti. Chest 1997;112(2):348.

OBJECTIVE: To determine the optimal treatment interval for administering albuterol metered dose inhaler (MDI) with a holding chamber to patients presenting to the emergency department (ED) with acute asthma. DESIGN: Prospective, randomized, double-blind study. SETTING: EDs of 2 affiliated teaching hospitals in the Bronx NY. PATIENTS: One hundred adult patients with acute asthma and $FEV_1 < 60\%$ predicted of normal. INTERVENTIONS. At entry ($t = 0$ min), eligible patients all openly received inhaled albuterol (6 puffs) via MDI with a spacer. Subsequently, in a double-blind fashion, they received 6 puffs of albuterol or placebo with new MDIs and spacers at 30, 60, and 90 minutes such that Group 1 ($n = 34$) received albuterol every 30 minutes, Group 2 ($n = 33$) every 60 minutes, and Group 3 ($n = 33$) at 120 minutes only. FEV_1 and vital signs were measured at $t = 0$ and at 15, 30, 60, 90, and 120 minutes following initial treatment. Potassium levels were measured at $t = 0$ and 120 minutes. Adverse events, the use of additional inhaled β-agonists or systemic corticosteroids, and hospitalization rates were recorded. MEASUREMENTS & RESULTS: At $t = 0$, the groups did not differ in age, FEV_1, or prescribed asthma medications. All groups showed significant improvement in FEV_1 ($p < 0.05$; $T = 120$ vs 0 min). The conditions of Groups 1 and 2 improved significantly more than those of Group 3, but did not differ compared to each other. The mean ± SEM change in FEV_1 ($t = 120$ vs 0 min) was 0.993 ± 0.108, 0.858 ± 0.135, and 0.321 ± 0.056 L, respectively, for the 3 groups. Separate analysis for patients with $FEV_1\% < 40\%$ or $> 40\%$ predicted showed similar results. However, patients who initially were low responders to albuterol treatment (< 15 percentage point increase at 15 min) improved significantly with 30 minute treatments compared to the other 2 treatment regimens. Patients who initially responded with > 15 percentage point increase in FEV_1 at 15 minutes following initial albuterol inhalation benefited equally from 30- or 60-minute treatments compared to 120 minutes. Potassium levels did not change significantly during the study. Adverse events and hospitalization rates were equivalent. After the conclusion of the study, group 3 patients required a greater number of β-agonist treatments prior to eventual discharge from the ED. CONCLUSIONS: For acute asthma, albuterol MDI with a holding chamber can be given optimally at 60-minute intervals with minimal adverse effects for the majority of patients. However, patients who initially demonstrate a low or poor bronchodilator response to albuterol should be given subsequent treatments at 30-minute intervals. This will optimize care and conserve resources for patients who will benefit the most.

Timing of the Occurrence of Pulmonary Embolism in Trauma Patients—Owings JT, Kraut E, Battistella F, Cornelius JT, O'Malley R. Arch Surg 1997;132(8):862.

OBJECTIVE: To determine how soon after trauma pulmonary embolism (PE) occurs and if there is an association between the duration of this interval and mortality. DESIGN: Retrospective case series. PATIENTS: All patients admitted to our trauma service with established PE (pulmonary embolism) based on high probability findings on ventilation perfusion scan, positive results on a pulmonary arteriogram, or autopsy from July 1, 1990 to September 30, 1995. MAIN OUTCOME MEASURE: Time interval between injury and PE. SETTING: Level I university trauma center.



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RESULTS: Of 18,255 trauma patients identified, 63 met our criteria for PE (30 using a pulmonary arteriogram; 26, a ventilation perfusion scan; and 7, autopsy). Four patients (6%) had a documented PE on Day 1 following injury. Mortality was not correlated with the interval between injury and PE. Of the 63 patients, 58 (92%) had 1 or more established risk factors for thromboembolism. The ratio of P_{aO_2} to F_{IO_2} was the only factor predictive of mortality ($p = 0.02$, logistic regression analysis). CONCLUSIONS: Pulmonary embolism occurs in the immediate period following injury. Aggressive workup in patients with signs consistent with PE should be instituted promptly. Trauma patients who have at least 1 risk factor for thromboembolism should receive prophylaxis as soon after injury as possible.

Long-Term Outcome of Pulmonary Rehabilitation in Patients with COPD—CAJ Ketelaars, HH Abu-Saad, MAG Schlösser, R Mostert, EFM Wouters. Chest 1997; 112(2):363.

BACKGROUND: This study investigates the long term benefits of pulmonary rehabilitation in terms of health-related quality of life (HRQL). Such information is of particular importance in developing strategies for aftercare at home which aim to maintain the initial improvements seen after rehabilitation. METHODS: Criteria for inclusion were diagnosis of COPD, age 40 to 80 years, and completion of an inpatient pulmonary rehabilitation program. HRQL was assessed by the St George Respiratory Questionnaire, and the component "well-being" from the Medical Psychological Questionnaire for Lung Diseases. Patient characteristics included lung function parameters such as FEV_1, the diffusion capacity for carbon monoxide and maximal inspiratory mouth pressure, age, socioeconomic variables, and exercise tolerance evaluated by a 12-minute walking test. To define patients in whom long-term benefits were sustained 9 months postdischarge, cases were clustered using hierarchical cluster analysis, based on the HRQL scores at discharge. RESULTS: Complete data sets were obtained from 77 patients. Two groups of cases were clustered. Patient characteristics were essentially the same in both groups. HRQL differed significantly between groups on admission, at discharge, and at follow-up. Within-group analysis revealed that patients in Group 1 ($n = 44$) had "moderate" scores on HRQL on admission, a significant improvement between admission and discharge, followed by a significant deterioration of HRQL at follow-up. Group 2 ($n = 33$) had "severely" impaired HRQL on admission, little improvement after rehabilitation, and remained in fairly stable condition 9 months postdischarge. CONCLUSIONS: Results suggest that patients with COPD require a differentiated aftercare program of postdischarge pulmonary rehabilitation.

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Economic Analysis of Respiratory Rehabilitation—RS Goldstein, EH Gort, GH Guyatt, D Feeny. Chest 1997;112(2):370.

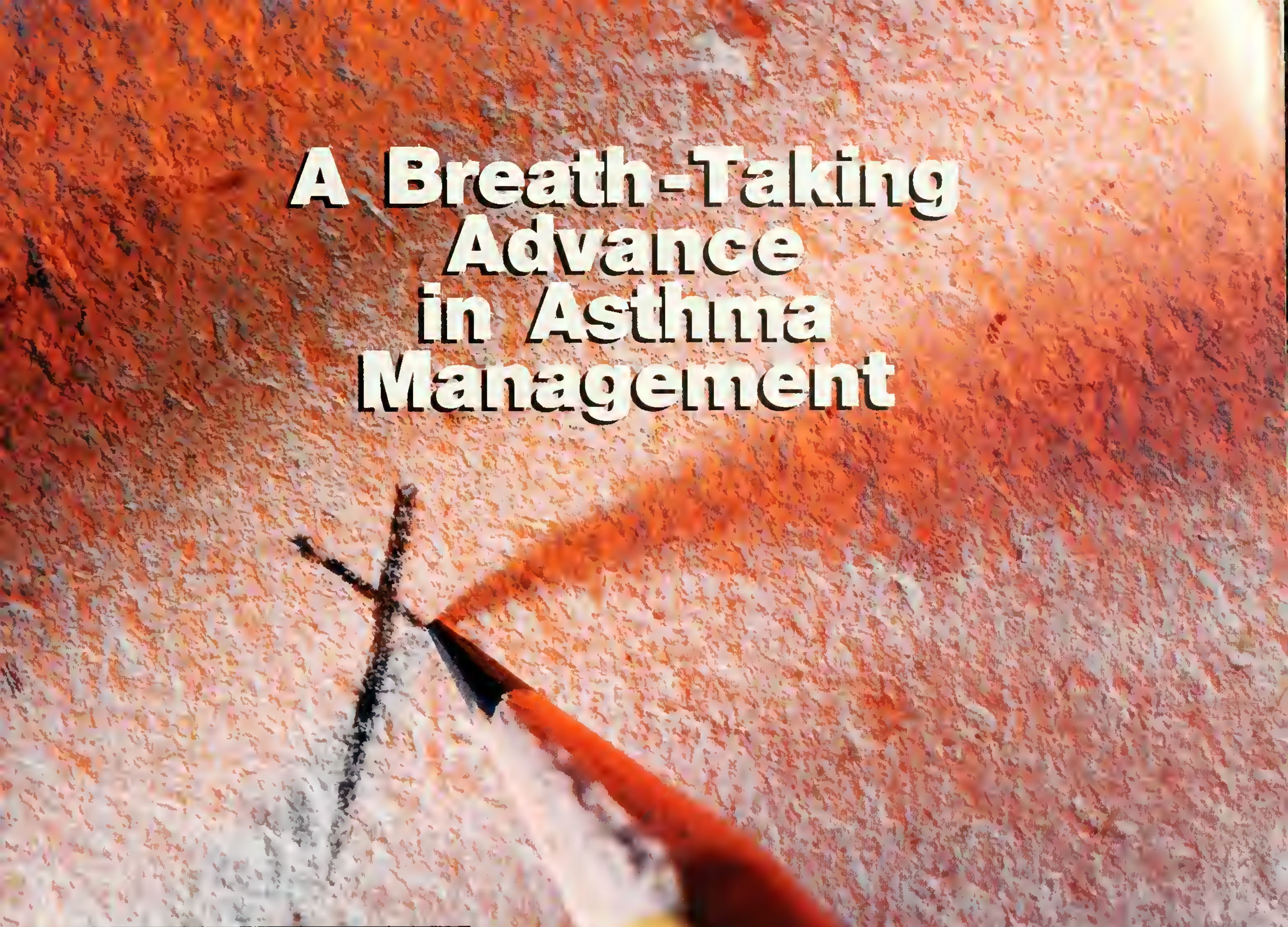
OBJECTIVE: We report on the incremental costs associated with improvements in health-related quality of life (HRQL) following 6 months of respiratory rehabilitation compared with conventional community care. DESIGN: Prospective randomized controlled trial of rehabilitation. SETTING: A respiratory rehabilitation unit. PARTICIPANTS: Eighty-four subjects who completed the rehabilitation trial. INTERVENTION: Two months of inpatient rehabilitation followed by 4 months of outpatient supervision. MEASUREMENTS & RESULTS: All costs (hospitalization, medical care, medications, home care, assistive devices, transportation) were included. Simultaneous allocation was used to determine capital and direct and indirect hospitalization costs. The incremental cost of achieving improvements beyond the minimal clinically important difference in dyspnea, emotional function, and mastery was $11,597 (Canadian). More than 90% of this cost was attributable to the inpatient phase of the program. Of the nonphysician health-care professionals, nursing was identified as the largest cost center, followed by physical therapy and occupational therapy. The number of subjects needed to be treated (NNT) to improve 1 subject was 4.1 for dyspnea, 4.4 for fatigue, 3.3 for emotion, and 2.5 for mastery. CONCLUSIONS: Cost estimates of various approaches to rehabilitation should be combined with valid, reliable, and responsive measures of outcome to enable cost-effectiveness measures to be reported. Comparison studies with the same method are necessary to determine whether the improvements in HRQL that follow inpatient rehabilitation are cheap or expensive. Such information will be important in identifying the extent to which alternative approaches to rehabilitation can influence resource allocation. A consideration of cost-effectiveness from the perspective of NNT may be useful in the evaluation of health-care programs.

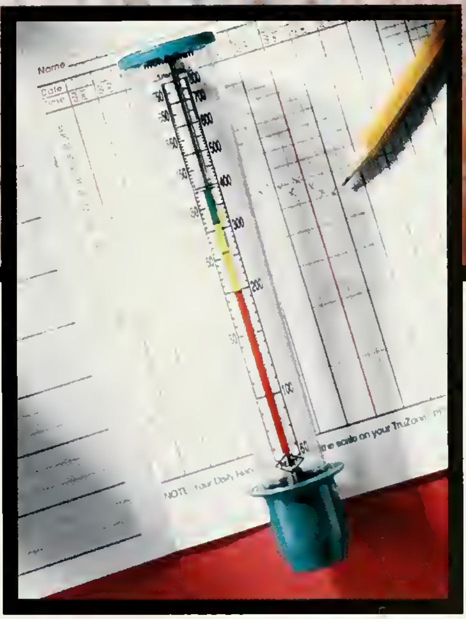
Quality Control of Peak Flow Meters for Multicenter Clinical Trials—CG Irvin, RJ Martin, VM Chinchilli, SJ Kunselman, RM Cherniack, and The Asthma Clinical Research Network. Am J Respir Crit Care Med 1997;156:396.

Although peak expiratory flow (PEF) measurements are recommended for monitoring and assessing treatment of asthmatic patients, and widely employed to assess outcome in clinical trials and epidemiologic studies, information about performance of peak flow meters (PFM) under field conditions is lacking. We describe a simple testing system consisting of a testing chamber, a spirometer, and a calibration syringe to evaluate the relative accuracy or median relative bias (MRB), precision, or interquartile range (IQR) of the mini-Wright PFM. The relative accuracy ranged from -4.4 to 13.2% (mean, 4.1%) and the precision from 0.06 to 11.5% (mean, 1.2%). Durability of this PFM was assessed during a 26-week clinical trial in 255 asthmatic subjects at 5 centers. Seventy-one PFM (19.9%) were identified as having failed to meet acceptance criteria, predominantly because of loss of relative accuracy, by the clinics at follow-up visits ($n = 36$), and by the Data Coordinating Center on retrospective review of quality control measurements submitted by the clinics ($n = 35$). This study indicates that a simple device can be used to evaluate the relative accuracy and precision of a given PFM and to ensure the quality of PEF measurements during a clinical trial. To the extent that one can extrapolate these data to other devices, our findings indicate that the failure rate of PFM over time can be high, indicating that quality control of a PFM over time is absolutely essential in clinical trials as well as in routine clinical care.

Ultrasonic Nebulization for Efficient Delivery of Surfactant in a Model of Acute Lung Injury: Impact on Gas Exchange—R Schermuly, T Schmehl, A Günther, F Grimminger, W Seeger, D Walmrath. Am J Respir Crit Care Med 1997; 156:445.

We investigated the effect of ultrasonic nebulization versus instillation of exogenous surfactant on gas exchange abnormalities provoked by detergent inhalation in perfused rabbit lungs. Ven-





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tilation-perfusion ($\dot{V}_A/\dot{Q}$) distribution was assessed by the multiple inert gas elimination technique. For nebulization of natural bovine surfactant (Alveofact®), an ultrasonic device was placed in line with the inspiratory gas flow tubing, manufacturing particles with a mass median aerodynamic diameter of ~ 4.5 μM and high aerosol concentration. In vitro studies demonstrated biochemical and biophysical integrity of postnebulization surfactant. Lung aerosol deposition was monitored by a laser-photometric technique. In lungs with sham inhalation of saline, tracheal instillation of surfactant (~ 11 mg/kg body weight, infused over 50 min) provoked substantial $\dot{V}_A/\dot{Q}$ mismatch and limited shunt flow, whereas lung surfactant deposition by ultrasonic nebulization (~ 7 to 9 mg/kg body weight; nebulization time, 50 min) did not interfere with physiologic gas exchange. Tween 20 inhalation provoked severe $\dot{V}_A/\dot{Q}$ mismatch with predominant shunt-flow (~ 21%). This was not reversed by "rescue" application of instilled surfactant, but largely reversed by nebulized surfactant (shunt reduced to 5.5%; $p < 0.01$). Analysis of postaerosol lavage fluid demonstrated partial reconstitution of surface activity by nebulized surfactant. We conclude that ultrasonic nebulization may be employed for efficient delivery of functionally intact natural surfactant to the distal bronchoalveolar space. This approach effects rapid improvement of gas exchange in a model of acute homogeneous lung injury.

Extubation Outcome after Spontaneous Breathing Trials with T-Tube or Pressure Support Ventilation—A Esteban, I Alía, F Gordo, R Fernández, JF Solsona, I Vallverdú, et al for The Spanish Lung Failure Collaborative Group. Am J Respir Crit Care Med 1997;156:459.

A 2-hour T-tube trial of spontaneous breathing was used in selecting patients ready for extubation and discontinuation of mechanical ventilation. However, some doubt remains as to whether it is the most appropriate method of performing a spontaneous breathing trial. We carried out a prospective, randomized, multicenter study involving patients who had received mechanical ventilation for more than 48 hours and who were considered by their physicians to be ready for weaning according to clinical criteria and standard weaning parameters. Patients were randomly assigned to undergo a 2-hour trial of spontaneous breathing in 1 of 2 ways: with a T-tube system or with pressure support ventilation of 7 cm H_2O. If a patient had signs of poor tolerance at any time during the trial, mechanical ventilation was reinstituted. Patients without these features at the end of the trial were extubated. Of the 246 patients assigned to the T-tube group, 192 successfully completed the trial and were extubated; 36 of them required reintubation. Of the 238 patients in the group receiving pressure support ventilation, 205 were extubated, and 38 of them required reintubation. The percentage of patients who remained extubated after 48 hours was not different between the 2 groups (63% T-tube, 70% pressure support ventilation, $p = 0.14$). The percentage of patients failing the trial was significantly higher when the T-tube was used (22 vs 14%, $p = 0.03$). Clinical evolution during the trial was not different in patients reintubated and successfully extubated. ICU mortality among reintubated patients was significantly higher than in successfully extubated patients (27 vs 2.6%, $p < 0.001$). Spontaneous breathing trials with pressure support or T-tube are suitable methods for successful discontinuation of ventilator support in patients without problems to resume spontaneous breathing.

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Mechanical Ventilation with or without Daily Changes of In-Line Suction Catheters—MH Kollef, D Prentice, SD Shapiro, VJ Fraser, P Silver, E Trovillion, et al. Am J Respir Crit Care Med 1997;156:466.

The purpose of this study was to determine the safety and cost-effectiveness of not routinely changing in-line suction catheters for patients requiring mechanical ventilation. Patients were randomly assigned to receive either no routine in-line suction catheter changes (n = 258) or in-line suction catheter changes every 24 hours (n = 263). The main outcome measure was the incidence of ventilator-associated pneumonia. Other outcomes evaluated included hospital mortality, acquired organ system derangements, duration of mechanical ventilation, lengths of intensive care and hospital stay, and the cost for in-line suction catheters. Ventilator-associated pneumonia was seen in 38 patients (14.7%) receiving no routine in-line suction catheter changes and in 39 patients (14.8%) receiving in-line suction catheter changes every 24 hours (relative risk, 0.99; 95% CI, 0.66 to 1.50). No statistically significant differences for hospital mortality, lengths of stay, the number of acquired organ system derangements, death in patients with ventilator-associated pneumonia, or mortality directly attributed to ventilator-associated pneumonia were found between the 2 treatment groups. Patients receiving in-line suction catheter changes every 24 hours had 1,224 catheter changes costing a total of $11,016; patients receiving no routine in-line suction catheter changes had a total of 93 catheter changes costing $837. Our findings suggest that the elimination of routine in-line suction catheter changes is safe and can reduce the costs associated with providing mechanical ventilation.

No-Cut Thoracoscopic Lung Plication: A New Technique for Lung Volume Reduction Surgery—Swanson SJ, Mentzer SJ, DeCamp MM Jr, Bueno R, Richards WG, Ingenito EP, et al. J Am Coll Surg 1997;185(1):25.

BACKGROUND: Lung volume reduction surgery (LVRS) using a linear cutting stapler or laser ablation via median sternotomy or thoracoscopy is a current therapy for symptomatic emphysema. The primary causes of morbidity and mortality (as high as 20%) are existing comorbidities and prolonged air leaks secondary to visceral pleural division. We report a novel technique using minimally invasive techniques designed to achieve volume reduction while preserving the visceral pleura. A novel lung grasper and a knifeless stapler are used to permanently plicate lung tissue without cutting visceral pleura. STUDY DESIGN: This prospective analysis involves a consecutive series of patients who had LVRS using this method. Between May 1995 and September 1996, 32 patients underwent 50 unilateral, staged bilateral, or bilateral thoracoscopic lung plication procedures. The indications for LVRS were standard; they included severe limiting dyspnea (forced expiratory volume in 1 second [FEV_1] = 0.68 ± 0.05), hyperinflated lungs with flattened diaphragms on chest x-ray, and diffuse emphysema seen on chest computed tomography scan. Ventilation and perfusion scanning was used to identify potential ventilation and perfusion mismatch target areas of lung for plication. RESULTS: The right lung was plicated first in 25 of 32 patients (78%), and upper lobe plications predominated (77%). A mean of 9.3 ± 0.8 staple firings were used for each unilateral plication procedure. There were no perioperative deaths. Two patients (4%) required axillary thoracotomies to repair air leaks. Mean chest tube duration was 6.3 ± 0.5 days. Median hospital stay was 7 days (range 3-15). An Intensive Care Unit stay was required following 8 procedures (17%). Postoperative morbidity occurred in 18 (39%) of 46 procedures, including 5 cases of atrial fibrillation and 4 persistent (> 7 days) air leaks. A minimum 2-month follow-up was available for 22 patients (32 of 46 procedures), demonstrating

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a clear chest x-ray with significant improvement in ipsilateral diaphragmatic contour. Twelve patients had unilateral reduction, and 10 patients had bilateral reduction in either a staged (n = 7) or sequential at 1 operation (n = 3) fashion. Twenty-five (78%) of 32 procedures were associated with improved pulmonary function, with a mean increase in FEV_1, in patients in this subgroup of procedures, of 43 ± 7% for each ipsilateral plication at a mean follow-up of 3.8 ± 0.5 months. For the entire group of 32 procedures, the mean improvement in measured FEV_1 was 29 ± 7%. Supplemental oxygen requirement was significantly reduced in 9 of 16 patients following plication. CONCLUSION: These data suggest that minimally invasive surgical techniques coupled with a no-cut lung plication can achieve significant lung volume reduction with favorable postoperative morbidity and mortality. Lung plication appears to hold promise as an alternative technique of LVRS.

Effects of Inhaled Nitric Oxide on Gas Exchange in Lungs with Shunt or Poorly Ventilated Areas—SR Hopkins, EC Johnson, RS Richardson, H Wagner, M De Rosa, PD Wagner. Am J Respir Crit Care Med 1997;156:484.

Inhaled nitric oxide (NO) is a selective pulmonary vasodilator with beneficial effects on some lung diseases, yet conflicting results, particularly in chronic obstructive pulmonary disease, have been reported. We hypothesized that although inhaled NO would improve gas exchange in the presence of shunt (by increasing blood flow to normal areas), it could worsen gas exchange when areas of low ventilation-perfusion ($\dot{V}_A/\dot{Q}$) ratio were present since these areas could be preferentially vasodilated by NO. We examined how ~ 80 ppm inhaled NO altered pulmonary gas exchange in anesthetized ventilated dogs with the following: (1) normal lungs (n = 8), (2) shunt (n = 9, 24.7% shunt) produced by complete obstruction of 1 lobar bronchus, and (3) $\dot{V}_A/\dot{Q}$ inequality (n = 8) created by partial obstruction of 1 lobar bronchus resulting in a bimodal $\dot{V}_A/\dot{Q}$ distribution with 13% perfusion of low $\dot{V}_A/\dot{Q}$ areas ($0.005 < \dot{V}_A/\dot{Q} < 0.1$) without shunt. Inhaled NO significantly reduced pulmonary arterial ($p < 0.001$) and wedge pressures ($p < 0.01$) and pulmonary vascular resistance ($p < 0.01$) without changing cardiac output in each group. In normal lungs, NO did not alter P_{aO_2} or $\dot{V}_A/\dot{Q}$ inequality. However, with complete obstruction, shunt fell slightly ($p < 0.001$) with NO. In lungs with $\dot{V}_A/\dot{Q}$ inequality, NO variably affected $\dot{V}_A/\dot{Q}$ matching, which was improved in some dogs and worsened in others. In these lungs, changes in pulmonary vascular resistance of the abnormal area of the lung were negatively correlated with changes in $\dot{V}_A/\dot{Q}$ dispersion (logSD$\dot{Q}$) ($R = -0.85$, $p < 0.01$) and positively correlated with P_{aO_2} ($R = 0.79$, $p < 0.05$). We conclude that NO has net effects on pulmonary gas exchange, depending on the underlying lung pathology consistent with competing vasodilatory effects on the normal and abnormal areas that receive the gas.

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Lobectomy with Extended Lymph Node Dissection by Video-Assisted Thoracic Surgery for Lung Cancer—Kaseda S, Hangai N, Yamamoto S, Kitano M. Surg Endosc 1997;11(7):703.

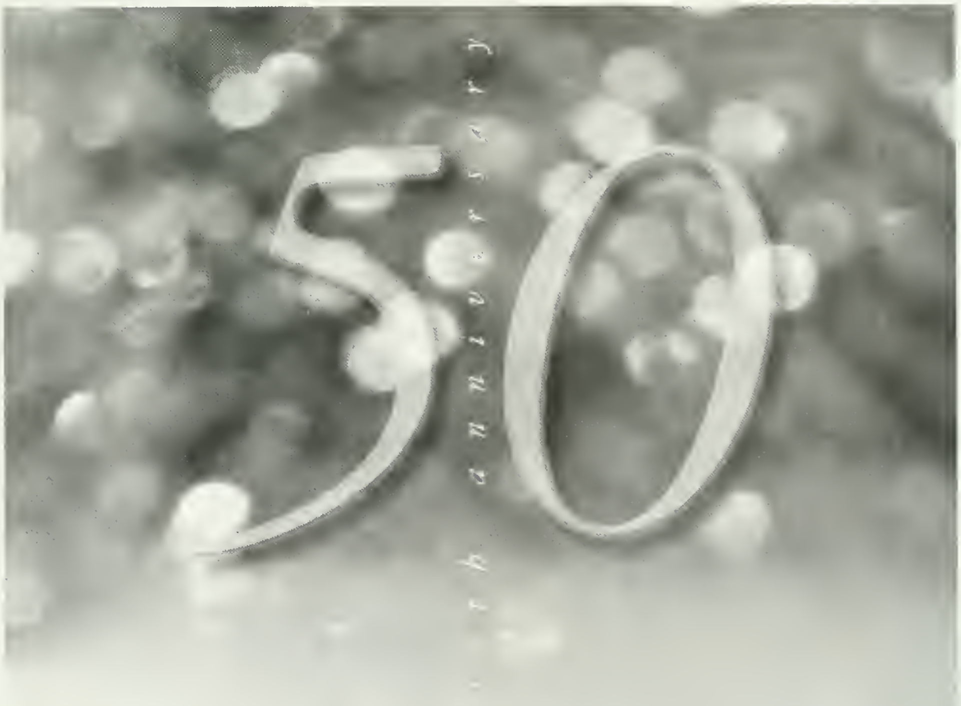
BACKGROUND: Between September 1992 and September 1996, we performed 88 VATS (video-assisted thoracic surgery) lobectomies and 2 VATS pneumonectomies. METHODS: The indications for surgery were 68 cases of lung cancer, 9 cases of bronchiectasis, 6 cases of tuberculosis, and 7 cases of benign lesions. Of the 68 cases of lung cancer, 36 were treated by VATS lobectomy with extended lymph node dissection for clinical Stage I lung cancer, making full use of recently developed devices for thoracoscopic surgery, such as roticulating endoscissors, miniretractors, endoclips, and harmonic scalpels. RESULTS: Twenty-four lymph nodes were resected on average (range, 10 to 51) by VATS. This number was comparable to lymph nodes resected in open thoracotomy during the same period. Among the 36 patients who underwent extended lymph node dissection, 20 showed no lymph node metastasis postoperatively (Stage I), while 16 had N1 or N2 cancer. All patients with Stage I cancer have survived 4 to 36 months (median: 17 months) with no signs of recurrence. CONCLUSIONS: This survival of Stage I lung cancer after VATS is comparable to that of open thoracotomy. We thus believe that VATS lobectomy with extended lymph node dissection can be an alternative to standard posterolateral thoracotomy for Stage I lung cancer.

***Mycobacterium Tuberculosis* Transmission from a Pediatrician to Patients**—Askew GL, Finelli L, Hutton M, Laraque F, Porterfield D, Shilkret K, et al. Pediatrics 1997;100(1):19.

The following report describes the contact investigation of a pediatrician with tuberculosis (TB). The pediatrician's disease was discovered in late February 1993 after tuberculin skin testing (TST) of his 15-month-old son was positive (13-mm induration). Further investigation to identify the source of the child's infection revealed a positive (15-mm induration) TST in the pediatrician. The pediatrician had been symptomatic with a cough since September 1992. The pediatrician had a chest radiograph that revealed numerous cavitary lesions and a sputum smear that was positive for acid-fast bacilli. An investigation was initiated to assess whether the transmission of *Mycobacterium tuberculosis* had occurred in the pediatrician's office to patients, families, or other visitors. The investigation was later extended to include the hospitals and the day care center where the pediatrician worked. METHODS: A letter was mailed to parents of children served by the practice, explaining the potential exposure to TB and requesting that all persons who visited the office after September 1, 1992 complete an interview and Mantoux TST. Mass interviewing, testing, and test interpretation within the practice took place 7 times during March and April 1993. RESULTS: At the completion of screening, 181 (87%) of 208 children who had close contact with the index case were reliably skin-tested and returned for interpretation. Three (1.7%) of the 181 children were TST-positive (≥ 5 mm). Thirty-seven (13%) of the 286 adults tested and returning for interpretations were TST-positive (≥ 10 mm). Thirty-two (86%) of the 37 adults who tested positive were foreign-born. CONCLUSION: This investigation highlighted the need for identifying childhood TB infection as a sentinel event for adult disease. It also demonstrated the difficulty associated with deciding the extent of contact investigation of a health care worker with TB. Finally, the investigation emphasized the importance of maintaining regularly scheduled and appropriate testing for TB infection in health care workers and the need for health care workers to be cognizant of their own risk and be able to identify, especially in themselves, signs and symptoms of potential TB disease.

Research Synthesis of Controlled Studies Evaluating the Effect of Hypocapnia and Airway Protection on Cerebral Outcome—Dexter F. J Neurosurg Anesthesiol 1997;9(3):217.

Hyperventilation is a standard method of treating patients with intracranial hypertension. I reviewed all the relevant peer-reviewed literature to identify the documented benefits of hyperventilation as treatment for cerebral disease. Studies were identified by searches of the MEDLINE database between 1966 and September 1996, interviews with experts, and reviews of reference lists. Retained manuscripts reported results of a human or animal controlled trial that tested effect of hyperventilation and/or systemic hypocapnia on mortality, histopathology, or neurologic examination. Studies could be either randomized or observational and need not have been blinded. I found that



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for no clinical studies of cerebral disease, other than in acute head injury patients, was there any suggestion of a clinical benefit from hyperventilation. Three controlled, observational studies examined effects of airway management and ventilatory support in head-injured patients. These studies found that maintaining such patients hypocapnic, versus spontaneously breathing without ventilatory support, decreased mortality. However, by design the studies could not establish whether hypocapnia itself contributed to the decreased mortality. Two clinical studies examined the effect of P_{aCO_2} itself in patients with head injury. In both, hypocapnic patients did not have better neurologic outcome. In conclusion, securing the airway and supporting ventilation probably reduces mortality in unconscious, neurosurgical patients. However, there are virtually no clinical data that hypocapnia improves outcome in patients with cerebral disease.

Pulmonary Vascular Complications of Chronic Airway Obstruction in Children—Jacobs IN, Teague WG, Bland JW Jr. Arch Otolaryngol Head Neck Surg 1997;123(7):700.

OBJECTIVE: To study the clinical presentation, treatment, and outcome of pulmonary artery hypertension (PAH) that develops in children with chronic airway obstruction. DESIGN: Case study. SETTING: Academic tertiary care children's hospital. PATIENTS: A 3-year (October 1, 1992 to September 30, 1995) review of the medical records of all children with chronic airway obstruction in whom PAH developed. MAIN OUTCOME MEASURE: The clinical course, including objective laboratory data to measure PAH (cardiac catheterization, echocardiography, electrocardiography) both before and after treatment. RESULTS: Pulmonary artery hypertension developed in 18 patients. It was diagnosed using cardiac catheterization in 13 patients and echocardiography in 5 patients. Obstructive problems include chronic lung disease (9 patients), tracheobronchomalacia (6 patients), adenotonsillar hypertrophy (5 patients), laryngomalacia (4 patients), macroglossia (5 patients), subglottic stenosis (2 patients), and pharyngeal collapse (2 patients). Nine patients were born prematurely and 7 had Down syndrome. Treatments included tracheotomy (7), adenotonsillectomy (5), adenoidectomy (3), laser epiglottoplasty (1), and supplemental oxygen (12). Fourteen patients had documented improvement of PAH as seen from the cardiac catheterization, echocardiography, or electrocardiography findings; in 4 patients, PAH worsened (3 deaths). CONCLUSIONS: Chronic airway obstruction may lead to PAH. In this study, PAH was more likely to develop in premature infants or children with Down syndrome and cardiac anomalies. Surgery or supplemental oxygen will usually improve PAH, but fixed and irreversible PAH developed in patients with the most severe airway disease.

"Refractoriness" of Airflow Obstruction Associated with Isolated Lymphocytic Bronchiolitis/Bronchitis in Pulmonary Allografts—Ross DJ, Marchevsky A, Kramer M, Kass RM. J Heart Lung Transplant 1997;16(8):832.

The clinical significance of an isolated "lymphocytic bronchiolitis/bronchitis" (Grade B) as detected in transbronchoscopic biopsy specimens (TBB) is unclear. We therefore have reviewed the spirometric responses associated with isolated Grade B diagnoses and contrasted them with episodes of "acute cellular rejection" (Grade A); the latter are manifested by "perivascular lymphocytic infiltration." Because lymphocytic bronchiolitis/bronchitis is considered a nonspecific histologic pattern that may be observed with either allograft rejection or respiratory infections, episodes were analyzed with respect to the presence (Grade B [+] CMV) or absence (Grade B [–] CMV) of cytomegalovirus infection. The maximum forced expiratory volume in 1 second (FEV_1) during the preceding 3 months was used as a baseline for computing percent change in FEV_1 coincident with transbronchoscopic biopsies ($\Delta\%FEV_1$ PRE) and maximum values obtained during the 3 months subsequent to specific therapies ($\Delta\%FEV_1$ POST). All episodes of acute cellular rejection (Grades A1 to 4) and symptomatic lymphocytic bronchiolitis/bronchitis (Grade B) were treated with "pulsed-dose" methylprednisolone, whereas intravenous ganciclovir was administered to patients at risk for recrudescence of cytomegalovirus. Between March 1, 1989 and September 1, 1995, 366 TBB procedures were performed for clinical indications in 57 lung transplant recipients. Histologic diagnoses with acceptable serial spirometric values included Grade A1 ($n = 9$), Grade A2 ($n = 27$), Grade A3 ($n = 2$), Grade B(–)CMV ($n = 25$), and Grade B(+)CMV ($n = 9$). The $\Delta\%FEV_1$ PRE coincident with TBB were not statistically different for the different histologic groups. For Grade A1, $\Delta\%FEV_1$ PRE was –14.6% ± 5.2% (M ± SEM); A2, –7.6% ± 1.8%; B(–)CMV, –14.8% ± 3.9%; and B(+)CMV, –14.8% ± 2.3%. After treatment, the $\Delta\%FEV_1$ POST, relative to baseline values, were for Grade A1, –8.8% ± 7.1%, A2, +0.26% ± 2.6%; B(–)CMV, –12.0% ± 3.8%; and B(+)CMV, –6.2% ± 2.8%. The $\Delta\%FEV_1$ POST values after pulsed methylprednisolone were significantly greater for histologic Grade A2 than Grade B(–)CMV (unpaired Student's *t* test, $p < 0.01$; 95% confidence interval for the difference of means: 3.34% to 21.2%). Grade A2 rejection was associated with spirometric improvement to within 10% of baseline values in 52% of episodes; whereas with Grade B(–)CMV, this salutary response was observed in only 32% of episodes. Bronchiolitis obliterans syndrome Stage 1b developed in 13 of 20 (65%) recipients, approximately 7.9 ± 3.4 months after detection of histologic Grade B and 21.2 ±9.5 months after transplantation. We conclude that the relative "refractoriness" of histologic Grade B most likely reflects a continuum of bronchiolitis obliterans after lung transplantation and, hence, may warrant different immunosuppressive strategies. Furthermore, spirometric decrement associated with acute cellular rejection (Grade A) may be ameliorated, but often not completely reversed, after pulsed methylprednisolone. We speculate that surveillance TBB may prove rewarding by enabling an earlier detection of these histologic diagnoses before the development of physiologic impairment.

Development and Validation of a Rhinoconjunctivitis and Asthma Symptom Score for Use as an Outcome Measure in Clinical Trials—Wasserfallen JB, Gold K, Schulman KA, Baraniuk JN. J Allergy Clin Immunol 1997;100(1):16.

BACKGROUND: The measurement of health outcomes has become a priority for assessing and containing health care costs. OBJECTIVE: To develop and fully validate a simple symptom scale

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assessing both asthma and rhinoconjunctivitis, 2 interdependent conditions. METHODS: A self-administered questionnaire of 31 items was tested in 102 patients with asthma and rhinoconjunctivitis between September 1992 and December 1994. The items were rated on a 6-point Likert scale ranging from none to extremely severe and included commonly recorded symptoms of inflammation such as irritation, congestion, and discharge in the skin, eyes, nose, sinus, pharynx, and chest. RESULTS: Validation included (1) responsiveness: scores for 18 patients evaluated during an emergency room visit were statistically significantly different from those recorded after recovery and in a control group of 24 patients with asthma; (2) reliability: external consistency was 0.8 at 1 week, and internal consistency was 0.8 for individual organs and 0.7 for individual symptoms; (3) validity: a 5-point scale better captured the distribution of values; irrelevant and redundant items were eliminated. The optimal questionnaire included 21 items. CONCLUSIONS: The symptom score was applicable, responsive, reliable, and valid. Used with existing validated tools such as treatment needs and quality of life assessment, it may provide a comprehensive picture of allergic airway disease for quality assurance or research purposes.

Prospective Evaluation of Computed Tomography and Mediastinoscopy in Mediastinal Lymph Node Staging—Gdeedo A, Van Schil P, Corthouts B, Van Mieghem F, Van Meerbeeck J, Van Marck E. Eur Respir J 1997;10(7):1547.

Precise mediastinal lymph node (LN) staging is imperative in otherwise operable non-small cell lung cancer (NSCLC), as it determines subsequent treatment and possible inclusion in a neoadjuvant trial. The roles of mediastinoscopy and computed tomography (CT) remain controversial. To determine the accuracy of current CT scanners, a prospective study was performed. From April 1993 until September 1995, 100 consecutive patients with NSCLC without distant metastases underwent staging by CT and cervical mediastinoscopy. Naruke's map was used for classification, and LNs larger than 1 cm were considered CT positive. There were 91 males and 9 females, with a mean age of 64 (range 45-82) years. Fifty-nine tumours were central and 41 peripheral, 64 right-sided and 36 left-sided. Thoracotomy with mediastinal LN sampling was performed in 74 patients, nonoperated patients having multilevel Stage IIIA or Stage IIIB disease. Twenty-five (25%) mediastinoscopies were positive and 3 were false-negative (3%). There were 29 false-positive CT scans and 12 false-negative. Overall sensitivity and specificity of CT were 63 and 57%, respectively, and of mediastinoscopy 89 and 100%, respectively. Positive and negative predictive values of CT were 41 and 77%, respectively, and of mediastinoscopy 100 and 96%, respectively. Accuracy of CT was 59% and of mediastinoscopy 97%. Accuracy of CT was lowest for left-sided and centrally located tumours, and for LN station 7. Even with current computed tomography scanners, sensitivity and specificity remain low. Although overall cost may increase, routine cervical mediastinoscopy is necessary for precise staging of non-small cell lung cancer, and subcarinal lymph nodes should be routinely sampled.

Seasonal Differences in Airway Hyperresponsiveness in Asthmatic Patients: Relationship with Allergen Exposure and Sensitization to House Dust Mites—van der Heide S, De Monchy JG, De Vries K, Dubois AE, Kauffman HF. Clin Exp Allergy 1997;27(6):627.

BACKGROUND: The degree of airway hyperresponsiveness in allergic asthmatic patients may be influenced by changes in environmental exposure to inhalant allergens. OBJECTIVE: This study investigates the relationship between seasonal changes in exposure to house dust mite (HDM) allergens and non-specific airway hyperresponsiveness in asthmatic patients with multiple sensitizations to inhaled allergens. METHODS: In 43 asthmatic patients sensitized to several inhalant allergens, lung function (FEV_1), airway hyperresponsiveness (PC20 histamine), serum total IgE, house dust mite (HDM) specific IgE and number of peripheral blood eosinophils were measured during autumn 1990 (September-November) and spring 1991 (March-May). During each season, floor dust samples were collected twice from living rooms and bedrooms and the concentration of the HDM allergens Der p 1 and Der p 2 determined. RESULTS: More severe airway hyperresponsiveness (lower PC20 histamine) during autumn was only found in patients sensitized to HDM ($n = 32$; autumn: 2.05 mg/mL, spring: 4.51 mg/mL [geometric means], $p < 0.01$), whereas in patients not sensitized to HDM ($n = 11$) similar values were observed in both seasons (3.44 and 4.52 mg/mL, respectively, $p = 0.56$). More severe airway hyperresponsiveness of HDM sensitized patients in autumn was significantly associated with higher Der p 1 concentrations in floor dust. Aside from airway hyperresponsiveness, seasonal changes in serum total IgE and number of peripheral blood eosinophils were seen in patients sensitized to HDM. CONCLUSIONS: In allergic asthmatic patients, airway hyperresponsiveness may increase during autumn, depending on sensitization to HDM and an increase of exposure to HDM allergen.

Percutaneous Dilatational Tracheostomy in a Medical ICU—Petros S, Engelmann L. Intensive Care Med 1997;23(6):630.

OBJECTIVE: To evaluate the safety of percutaneous dilatational tracheostomy. DESIGN: A prospective clinical study. SETTING: The intensive care unit of a university medical clinic. PATIENTS: 137 critically ill patients admitted between May 1993 and September 1996. INTERVENTION: Percutaneous dilatational tracheostomy at the bedside. RESULTS: The median duration of translaryngeal intubation prior to tracheostomy was 8 days. Tracheostomy was carried out within 12.8 minutes (range 7-30 min). Acute complications were documented in 11.0% of the patients. There was 1 case of severe bleeding with transient asphyxia. Four patients had tracheal mucosal laceration treated conservatively. The postoperative in-hospital complication rate was 5.1%, the sole problem being stomal bleeding. Only 2 cases of stomal infection were documented. There was no procedure-related mortality. CONCLUSION: In the hands of the experienced, percutaneous dilatational tracheostomy is a safe and quick bedside procedure. It is also less expensive and incurs minimal stress for the patient compared with the surgical method. The technique can be easily mastered by nonsurgical physicians and we feel that it is the method of choice for elective tracheostomy in the majority of intensive care patients.

Preoperative Pulmonary Function Tests Do Not Predict Outcome after Coronary Artery Bypass—Jacob B, Amoateng-Adjepong Y, Rasakulasuriar S, Manthous CA, Haddad R. Conn Med 1997;61(6):32.

PURPOSE: To evaluate the utility of preoperative pulmonary function tests in predicting postoperative complications and lengths of stay after coronary artery bypass grafting. METHODS: Medical records of 193 consecutive patients who underwent coronary artery bypass grafting from October 1993 to September 1994 were reviewed. Preoperative pulmonary function tests, comorbid conditions, smoking history, postoperative complications, and total days in the intensive care unit, hospital, and on mechanical ventilation were abstracted. Data were analyzed using linear regressions, analyses of variance, and nonpaired Student's *t* tests. RESULTS: Pulmonary function tests were normal in 56 subjects (29%, Group 1), mildly impaired in 72 (37%, Group 2), and moderately impaired in 35 (18%, Group 3). Thirty patients (16%) had no pulmonary function tests. Group 3 subjects were older (71) compared to Groups 1 and 2 (63 and 65, $p < 0.05$). There was no major difference in comorbid conditions or smoking status among the groups. All patients had atelectasis postoperatively. The most frequent postoperative complications were pleural effusions (43%), pulmonary edema or congestive heart failure (28%), and atrial fibrillation (35%). The repeat surgery rate was 3.6%. The mean length of hospital stay was 10.1 ± 0.6 days, with 1.5 ± 0.1 days of mechanical ventilation and 2.8 ± 0.2 days of intensive care unit stay. Overall, pulmonary function tests had no predictive value for postoperative pulmonary and nonpulmonary complications, nor for durations of mechanical ventilation and intensive care unit stay. There was a trend toward increased length of hospital stay in patients with impaired pulmonary function tests (Group 1, 8.6 ± 0.6; Group, 2 9.6 ± 0.8; Group 3, 12.7 ± 2.3 days, $p = 0.09$) but this was consistent with random variation. CONCLUSIONS: Preoperative pulmonary function tests were not useful in predicting postoperative outcomes in patients undergoing coronary artery bypass grafting.

Medium Term Results of Direct Bronchial Arterial Revascularisation Using IMA for Single Lung Transplantation—Yacoub M, Al-Kattan KM, Tadjkarimi S, Eren T, Khaghani A. Eur J Cardiothorac Surg 1997;11(6):1030.

OBJECTIVE: To describe a technique of direct revascularisation of the bronchial artery using the left IMA and assess its medium term results in patients undergoing left single lung transplant (SLT). METHODS: Between March 1991 and September 1993, 22 patients who underwent direct bronchial revascularisation at the time of left SLT (20 pedicled IMA, 1 free IMA, and 1 direct anastomosis to the aorta) have been followed up for a minimum period of 1 year (mean 30 ± 12 months). Their mean age was 47.8 ± 9.6 and the original disease was emphysema in 19, lymphangioleiomyomatosis in 2, and pulmonary fibrosis in one. The mean ischaemia time was 269.7 ± 23.4 minutes. RESULTS: There was 1 early death (4.5%) and 3 patients were re-explored for bleeding. The actuarial survival at 1 and 3 years was 91 ± 0.4% and 82.6 ± 1%, respectively. Bronchial healing was excellent in all patients and angiographic studies showed patent vascular anastomosis in all 22 patients, with good run off in 20 and poor in 2. One patient developed clinical obliterative bronchiolitis at 22 months (4.5%) during a period of follow-up varying from 12 to 43 months (mean 30 SD 12). At last follow-up the mean FEV$_1$ was 1.4 ± 0.4 and the mean FVC was 2.2 ± 0.6. On average, each patient developed 1.5 ± 0.6 infection episodes and 1 ± 0.2 acute lung rejection. CONCLUSION: It is concluded that the medium term results of direct bronchial revascularisation are good. However the influence of this procedure on long term-results needs further investigation.

Thoracoscopic Bilateral Lung Volume Reduction for Diffuse Pulmonary Emphysema—Stammberger U, Thurnheer R, Bloch KE, Zollinger A, Schmid RA, Russi EW, Weder W. Eur J Cardiothorac Surg 1997;11(6):1005.

OBJECTIVE: In a prospective study, we investigated the functional results, complications and survival of bilateral video-assisted thoracoscopic (VAT) lung volume reduction (LVR) in a selected group of patients with severe, nonbullous pulmonary emphysema. From January 1994 to September 1996, 42 of 143 candidates (13 female, 29 male, 42-78 years) were operated. They were short of breath on minimal exertion due to severe airflow obstruction and hyperinflation (FEV$_1$ < 30%) predicted, TLC > 130% predicted, RV > 200% predicted). METHODS: LVR was performed bilaterally by VAT using endoscopic staplers without buttressing the staple lines. Pulmonary function test (PFT), MRC dyspnea score and 12-minute walking distance were assessed preoperatively, at 3, 6, and 12 months. In addition lung function was measured at hospital discharge. RESULTS: The patients reported a marked relief of dyspnea, which persisted at all follow-up visits ($p < 0.001$). FEV$_1$ increased from 0.80 ± 0.24 (L) to 1.14 ± 0.41 (L) postoperatively, a 43% gain ($p < 0.001$). A relevant increase of FEV$_1$ persisted for at least 1 year. The residual volume to total lung capacity ratio decreased from 0.64 to 0.56 at hospital discharge. The mean 12-minute walking distance increased from 500 ± 195 (m) to 770 ± 222 (m) after 1 year ($p < 0.001$). The mean hospital stay was 13 ± 5.5 days (median 12.0), drainage time was 9 ± 4.3 (median 8.0) days. There was no 30-day mortality. Three patients died between 2 and 15 months postoperatively by nonsurgery related reasons. One patient underwent lung transplantation 5 months after surgical lung volume reduction. CONCLUSIONS: In a selected group of patients with severe, nonbullous pulmonary emphysema, bilateral LVR by VAT results in instantaneous postoperative improvement in pulmonary function and dyspnea. These favorable effects, including an amelioriation in exercise performance, lasted for at least 1 year.

A Practical Guide for the Diagnosis and Treatment of Pediatric Pneumonia—Jadavji T, Law B, Lebel MH, Kennedy WA, Gold R, Wang EE. Can Med Assoc J 1997;156(5):S703.

OBJECTIVE: To develop guidelines for the diagnosis and management of community-acquired pediatric pneumonia. OPTIONS: Clinical assessment, radiography, laboratory testing, and empirical antimicrobial therapy. OUTCOMES: Increased awareness of age-related causes, improved accuracy of clinical diagnosis, better utilization of diagnostic testing and the rational use of empirical antimicrobial therapy resulting in more rapid diagnosis, initiation of appropriate therapy and decreased morbidity and mortality. EVIDENCE: A MEDLINE search for relevant articles published from 1996 to September 1996 using the MeSH terms "pediatric," "pneumonia," "respiratory tract infection," "pneumonitis," "etiology," "diagnosis," "therapy," "antibiotics," "resistance," "radiology," "microbiology" and "biochemistry." VALUES: A hierarchical evaluation of the strength of evidence modified from the methods of the Canadian Task Force on the Periodic Health Examination was used. When application of the hierarchy was not feasible or appropriate, different evaluation criteria were used. BENEFITS, HARMS, & COSTS: Increased awareness of the causes of pneumonia, accurate diagnosis and prompt treatment should reduce costs associated with unnecessary investigations and complications due to inappropriate treatment. RECOMMENDATIONS: Age is the best predictor of the cause of pediatric pneumonia, viral pneumonia being most common during the first 2 years of life. The absence of a symptom cluster of respiratory distress, tachypnea, crackles, and decreased breath sounds accurately excludes the presence of pneumonia (Level-II evidence). Bacterial cultures of samples from the nasopharynx and throat have no predictive value; however, Gram staining and culture of sputum from older children and adolescents are useful (Level-III evidence). Oral antimicrobial therapy will provide adequate coverage for most mild to moderate forms of pneumonia in children (Level-III evidence). Parenteral therapy is typically reserved for neonates and patients with severe pneumonia admitted to hospital (Level-III evidence). VALIDATION: These recommendations are based on consensus of Canadian experts in infectious diseases and microbiology. They are the only guidelines to address antimicrobial treatment from an age-related, etiologic perspective. SPONSOR: The development of these guidelines and the technical support and assistance of Core Health Inc in preparing this manuscript were funded through an unrestricted educational grant from Abbott Laboratories Canada. The sponsoring company was not involved in determining the membership of the consensus group or the content of the guidelines.

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Comparison of Resting Energy Expenditure Measured by Indirect Calorimetry and the Harris-Benedict Equation in HIV-Infected Men of Normal Body Weight

Jennifer Muir Bowers MS RD, Robert W Scott RRT, and Neil M Ampel MD

The Harris-Benedict equation (HBE) is routinely used as a method of calculating energy needs, incorporating weight, height, gender, and age as primary factors. For patients with trauma, surgery, or sepsis, additional stress factors have been developed and applied to the HBE to more accurately estimate their energy requirements. However, no stress factor has been established for patients with human immunodeficiency virus (HIV) infection. The goal of this study was to compare resting energy expenditure (REE), as calculated by HBE (REE_{HBE}), to resting energy expenditure measured by indirect calorimetry (REE_{IC}) among a group of HIV-infected patients. Twenty-nine HIV-infected men at all stages of HIV infection underwent indirect calorimetry and had the HBE simultaneously calculated. All subjects were clinically stable and had near normal body weight at the time of the study. REE_{IC} and REE_{HBE} were highly and significantly associated ($r^2 = 0.983$; $p < 0.0001$) and REE_{IC} could be estimated by the equation $REE_{IC} = (REE_{HBE})(1.127)$. Using Bland-Altman analysis, the mean difference between REE_{IC} and REE_{HBE} was 206.4 kcals (95% CI, −366.4 to 739.2), suggesting a poor agreement between the two measures. REE_{IC} was not significantly associated with peripheral blood CD4 lymphocyte count or stage of HIV illness. These data suggest that even among stable male HIV-infected patients, the HBE equation may not accurately predict REE. [Respir Care 1997;42(11):1018-1021]

Introduction

Malnutrition contributes to both morbidity and mortality among individuals with human immunodeficiency type-1 (HIV) infection.[1,2] Factors contributing to malnutrition are multifactorial and include diminished nutrient intake, malabsorption, opportunistic infections, medication side effects, socioeconomic issues, and psychological causes.

Although there have been several publications regarding altered metabolism among persons infected with HIV, results have been conflicting. For example, Hommes and colleagues[3] found that asymptomatic HIV-infected men had a resting energy expenditure (REE) that was significantly higher than REE in uninfected control subjects; and Grunfeld and co-workers[4] found that REE increased with severity of HIV-associated illness. On the other hand, Macallan et al[5] reported that energy expenditure among HIV-infected men was not significantly different from reference energy expenditure values and found that energy expenditure was reduced in HIV-infected men during episodes of acute, rapid weight loss.

Various calculations have been proposed to determine energy requirements during nutrition assessment.[6] One of the most commonly used methods is the Harris-Benedict equation (HBE), which estimates basal energy expenditure based on gender, age, height, and weight.[7] The HBE was originally derived using healthy subjects and is a reasonable estimation

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of REE in these subjects.[6] Stress factors have been developed to assess total energy expenditure, depending on individual disease or injury.[8] However, no factors or recommendations for caloric needs have been developed specifically for HIV-infected patients.[9,10]

Indirect calorimetry has been found to be a reliable and accurate way to estimate REE.[11] However, compared to the HBE, it requires both extra time and equipment. In this study, we endeavored to ascertain if REE varied significantly between that estimated by the HBE and that by indirect calorimetry, and if so, whether specific characteristics, such as stage of HIV illness, or levels of serum albumin, transferrin, or cholesterol affected results. Our goal was to determine whether a specific factor or factors could be applied to the HBE that would more accurately estimate energy requirements in patients with HIV infection.

Methods

Subject Population

Twenty-nine male volunteers were recruited from the HIV Clinic at the Tucson Veterans Affairs Medical Center and studied between May and December 1995. All subjects had documented HIV infection, were not hospitalized or acutely ill, and had stable body weights at the time of the study. The study was approved by the Human Subjects Committee of the University of Arizona, and informed consent was obtained from each subject.

Subject Measurements

Height, weight, and age were recorded on all subjects at the time of study. Usual body weights (UBW) were as reported by the subjects. Ideal body weights (IBW) were obtained by calculating the midpoint of the weight ranges from the 1983 Metropolitan Height-Weight Tables[6] based on the patients' height and gender. IBW% (weight/IBW × 100) and UBW% (weight/UBW × 100) were calculated for each subject. Serum values of albumin, transferrin, cholesterol, and the peripheral blood CD4 lymphocyte count were obtained within 1 month of the study.

Indirect Calorimetry

Resting energy expenditure was measured by indirect calorimetry (REE_{IC}) using a Sensor Medics 2900 Metabolic Measurement Cart (Yorba Linda CA) by a respiratory therapist trained in its use. The cart uses a mass flow meter, a zirconium oxygen analyzer, and a non-dispersed infrared carbon dioxide analyzer, with an open circuit collection technique. REE_{IC} studies were performed in a quiet, temperature-controlled (24 °C) room on subjects who had fasted for 6 to 8 hours and had rested prone for 20 to 30 minutes before the test. At the time of measurement, a translucent blue plastic hood attached by a flexible hose to the metabolic cart was placed over the subject's head. During the 20-25 minute period of measurement, subjects were instructed to lie still, breathe normally, and not fall asleep. Oxygen consumption ($\dot{V}_{O_2}$) and carbon dioxide production ($\dot{V}_{CO_2}$) were measured from expired air. REE_{IC} per day was measured using the abbreviated Wier equation:[12]

$$REE_{IC}/\text{day (kcals)} = [(3.94)(\dot{V}_{O_2}) + (1.11)(\dot{V}_{CO_2})]\ 1440.$$

Energy Expenditure Calculation from the HBE

Resting energy expenditure was calculated using the original HBE (REE_{HBE})[13] to 1 significant digit:

$$REE_{HBE}/\text{day (kcals)} = 66.473 + (13.75)(\text{Weight in kg}) + (5.0033)(\text{Height in cm}) - (6.755)(\text{Age in years}).$$

Statistical Analysis

Median and range were calculated for continuous variables. Simple linear regression analysis without y-intercept was used to compare REE_{IC} to REE_{HBE}, and tests of correlation were used to determine the association between REE and continuous clinical variables.[14] The method of Bland and Altman[15,16] was used to determine the level of agreement between REE_{IC} and the REE_{HBE}. To do this, the difference between REE_{IC} and REE_{HBE} was plotted against the average value for REE_{IC} and REE_{HBE} for each subject. From this, the mean and 95% confidence interval (CI) for the differences between REE_{IC} and REE_{HBE} were calculated.[17]

Results

Data on the 29 HIV-infected male subjects are shown in Table 1. As can be seen, IBW% was slightly but not significantly depressed for the group and the median serum albumin and cholesterol levels were within normal limits. The median peripheral blood CD4 lymphocyte count was below 200/μL, indicating a significant level of immunodeficiency in this cohort. Plasma levels of HIV RNA were not available at the time of study.

As displayed in Figure 1, REE_{HBE} and REE_{IC} were significantly associated. On the basis of this, REE_{IC} could be estimated using a correction factor of 1.127 to REE_{HBE} ($r^2 = 0.983$, $p < 0.0001$). This relationship was similar for subjects whose IBW% was >100 and ≤100 (data not shown). However, when assessed by Bland-Altman analysis, the degree of agreement between REE_{IC} and REE_{HBE} was poor and varied with the average REE value (Fig. 2). The bias, or mean difference between the REE_{IC} and REE_{HBE}, was 206.4 kcals/day (95% CI, −326.4 to 739.2).

Table 1. General characteristics of the 29 HIV-infected men in the study.

Characteristic	N	Median	Range
Age (years)	29	40	28–69
Weight (kg)	29	66.4	47.3–132.7
UBW (kg)	29	72.7	58.0–123.2
UBW%	29	93.7	77.3–107.7
IBW (kg)	29	75.5	51.1–91.9
IBW%	29	91.9	67.4–144.4
CD4 lymphocyte count/μL	29	173	5–1183
CD4 count (%)	29	9	1–43
Albumin (g/dL)	29	3.8	2.1–4.6
Cholesterol (mg/dL)	17	124	85–209
Transferrin (mg/dL)	12	269	194–404

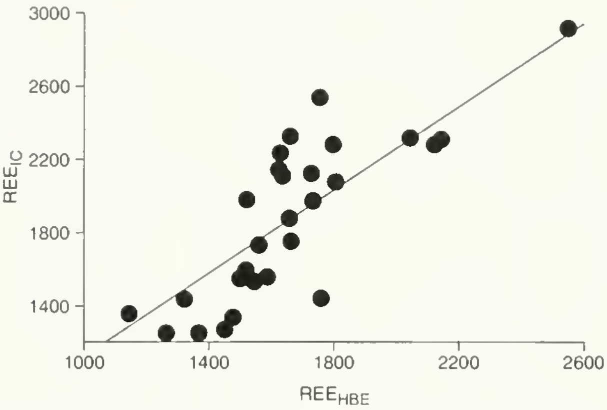

Fig. 1. Linear regression analysis without y-intercept comparing the energy expenditure, as measured by the HBE (REE_{HBE}, x-axis), to the resting energy expenditure (REE_{IC}, y-axis), as measured by indirect calorimetry.

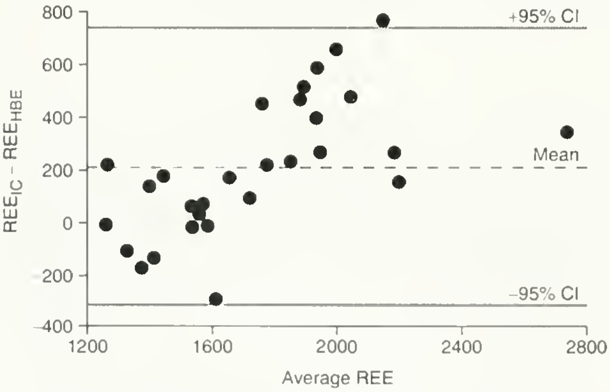

Fig. 2. Bland-Altman analysis[15] plotting the average value of resting energy expenditure (average REE in kcals/day, x-axis) measured by indirect calorimetry (REE_{IC}) and by the HBE (REE_{HBE}) against the difference in REE in kcals/day between the 2 methods (y-axis). CI indicates confidence interval.

No significant correlation was found between REE_{IC} and serum albumin, CD4 lymphocyte count, cholesterol, or transferrin among the subjects. However, the UBW% was positively and significantly correlated to REE_{IC} (Table 2). In addition, there was no significant association between REE_{IC} and whether the patient had a clinical diagnosis of acquired immunodeficiency syndrome, or AIDS ($p = 0.606$).

Table 2. Correlation between resting energy expenditure as measured by indirect calorimetry and other factors.

Factor	N	Correlation Coefficient	95% Confidence Interval	p Value
Albumin	29	−0.18	−0.51 to 0.20	0.351
CD4 count/μL	29	−0.12	−0.47 to 0.25	0.524
UBW%	29	0.39	0.02 to 0.66	0.037
Cholesterol	17	0.10	−0.40 to 0.56	0.695
Transferrin	12	−0.24	−0.73 to 0.37	0.429

UBW% = percent of usual body weight.

Discussion

Accurate energy requirement calculations are important in HIV-infected patients because inadequate energy consumption can result in weight loss. Weight status is directly correlated with length of survival in HIV infection.[1] The results of this study demonstrate that a commonly used method to estimate energy expenditure, the HBE, resulted in an overall underestimation when compared to indirect calorimetry. Such a deficit, if not corrected over time, could result in marked weight loss with a resultant decrease in immune function and an increased susceptibility to infection and other opportunistic processes in patients infected with HIV.[18]

This was a relatively small study using an all male HIV-infected population in which none of the subjects was acutely ill and none was experiencing acute, significant weight loss at the time of study. Therefore, caution must be exercised in generalizing these results to other groups of HIV-infected individuals, particularly to women and to those acutely ill with evidence of malnourishment. However, these results indicate that not only does the HBE tend to underestimate caloric needs among HIV-infected patients, but that there is a poor agreement between REE_{HBE} and REE_{IC} when values are assessed by Bland-Altman analysis. These data suggest that the values obtained for energy expenditure by HBE and indirect calorimetry may not be interchangeable. Future studies using larger numbers of subjects with broader ranges of body weights and clinical illness will be required to more precisely address this issue.

Adequate energy intake is vital in HIV-infected patients to prevent exacerbation of their compromised nutritional status. The measurement of REE by indirect calorimetry is based on both oxygen consumption and carbon dioxide excretion[11] and allows for a more accurate determination of energy expenditure than the HBE,[19] which is based on weight, height, and age. If the HBE is used to determine the caloric requirements of a stable man with HIV infection, our data suggest that a 1.127 stress factor should be applied. A better approach, however, might be to measure energy expenditure by indirect calorimetry. Energy requirements may need to be further adjusted if fever, infection, or malabsorption are present or if there has been recent trauma or surgery.[6,8]

Conclusion

In HIV-infected men of normal body weight, HBE underestimates energy expenditure measured by indirect calorimetry by a factor of 1.127. By Bland-Altman analysis, measurement of energy expenditure by HBE and indirect calorimetry are not in close agreement. Of clinically measurable factors associated with HIV infection and nutrition, REE^{IC} was found to be significantly correlated only with UBW%.

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Is Tracheal Pressure Ventilator Control Comparable to an Equivalent Level of Pressure Support Ventilation?

Paul B Blanch BA RRT and Michael J Banner PhD RRT

INTRODUCTION: An additional resistive work of breathing is imposed by the breathing apparatus (endotracheal tube [ETT] plus ventilator) upon all spontaneously breathing patients (WOB_I) receiving ventilatory support, predisposing some to respiratory muscle fatigue and ventilator weaning intolerance. Manually setting a level of pressure support ventilation (PSV) and tracheal pressure ventilation control (TPVC) has been advocated for managing patients adversely affected by WOB_I. TPVC differs from PSV by requiring the site of ventilator control to be located at the carinal end of the ETT instead of within the breathing circuit and by automatically and continuously adjusting the level of positive pressure applied. We sought to determine which patients are likely affected by increased WOB_I and to compare TPVC and PSV. MATERIALS & METHODS: Using a spontaneously breathing lung model, we varied spontaneous effort by gradually increasing the peak inspiratory flow (PIFR) and tidal volume (V_T) and measured WOB_I during continuous positive airway pressure (CPAP), PSV, and TPVC at 13 different flows and volumes. Under the 13 conditions, we measured PIFR, airway pressure, and V_T provided by TPVC and an equivalent level of PSV. RESULTS: The model clearly demonstrates that WOB_I changes directly with PIFR and V_T, ie, the greater the demand the greater the WOB_I and vice versa. When compared to TPVC at high inspiratory demands, CPAP at 5 cm H_2O and PSV at 5 cm H_2O resulted in significantly greater WOB_I than TPVC (0.98 and 0.89 vs 0.20 J/L, respectively). Furthermore, under most conditions, when compared to manually setting an equivalent level of PSV, TPVC provides significantly higher flows (118 vs 96 L/min) and a V_T closer to that demanded by the patient. CONCLUSIONS: Labile breathing patterns result in variations in PIFR and V_T that directly affect WOB_I. Thus, whenever breathing patterns change, patients require different levels of PSV to compensate for changing levels of WOB_I. When compared to a manually-set level of PSV, TPVC proved more responsive, was in closer synchrony with the patient, was capable of providing automatic and variable levels of pressure assist, and was able to compensate for most of the WOB_I encountered. [Respir Care 1997;42(11):1022-1033]

Introduction

Therapeutic advantages gained by mechanical ventilation include the maintenance of adequate gas exchange and a decrease in physiologic work of breathing (WOB_{PHYS}). Current ventilatory practice allows most patients to breathe spontaneously, particularly during the weaning process. However, virtually all unassisted and many assisted breaths are encumbered by an additional, predominantly flow-resistive, workload known as the imposed work of breathing (WOB_I), ie, the work performed by the patient to breathe spontaneously through the entire breathing apparatus. Under most circumstances, WOB_I is determined primarily by the endo-

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tracheal tube (ETT).[1,2] Nevertheless, measurable pressure drops exist across each of the remaining components of the breathing apparatus and, thus, each contributes to the total WOB_I. The breathing apparatus is properly defined as the ETT, ventilator, breathing circuit, and humidifier.[3] In addition to flow-resistive work, mechanical ventilators introduce other, more complex factors contributing to WOB_I: the work to trigger a ventilator ON (ie, to initiate inspiratory flow),[4] the relative flow or pressure target used during the post-trigger phase,[5] and breath termination (cycling) criteria.[4] Intubated and spontaneously breathing patients, therefore, encounter a total work of breathing (WOB_{TOT}) that exceeds their own WOB_{PHYS},[5-9] stated mathematically:

$$WOB_{TOT} = WOB_{PHYS} + WOB_I \qquad [1]$$

For some patients, WOB_I represents a formidable additional workload.[1-12] To help patients overcome WOB_I, pressure support ventilation (PSV) is frequently recommended.[6,8,10] However, our experiences, prior to the advent of PSV, suggest that not all ventilator patients require PSV. Colgan et al[13] studied respiratory mechanics, blood gases, and intrapulmonary shunting in patients before and after extubation and discovered that, for most patients, the ETT has no effect on these variables. Nunn et al[14] reported that patients tolerate fixed upper airway obstruction, except when minute ventilation becomes abnormally high. It follows that while some ventilator patients tolerate WOB_I, others do not. For the clinician, this poses a 2-part dilemma: Which patients require additional ventilatory assistance to overcome WOB_I, and How much support do they need? If we provide too much ventilatory support, the respiratory muscles do little or no work, predisposing them to disuse atrophy.[15] Insufficient support risks respiratory muscle fatigue. In either case, the duration of mechanical ventilation may be needlessly prolonged—for reconditioning if respiratory muscles atrophy and for rest if they are chronically fatigued.[15]

Several years ago, we reported[7] a related finding—one that offered a potential solution to the conundrum surrounding the issue of WOB_I (that is, if the airway-pressure-sensing line of a mechanical ventilator is repositioned to sense pressure at the distal or carinal end of the ETT, WOB_I during spontaneous breathing can be dramatically reduced). Under some study conditions, WOB_I was reduced by nearly 400%.[7] These findings have since been reaffirmed[16] and described in greater detail using an in-vitro model[5] and in patients with acute respiratory failure.[12] The strategy of relocating the pressure-sensing site was originally termed tracheal pressure-triggering (TPT) to distinguish it from conventional airway pressure-triggering (CPT). In retrospect, it seems that this term may have been misleading because most modern mechanical ventilators use pressure signals (usually derived at or near the Y–piece of the breathing circuit) for more than simply triggering. In addition to triggering, modern ventilators use these same pressure signals, in combination with high-speed flow valves and microprocessors, to form feed-back loops capable of precisely regulating the level of pressure applied and in determining the precise moment to terminate each breath (cycling). Changing the pressure-sensing location to the carinal end of the ETT affects the entire process often referred to as ventilator control. In light of this, the term TPVC seems not only more accurate, but more descriptive as well; we therefore employ it throughout this paper.

TPVC has been found useful not only for its work-sparing effects but also for its ability to automatically increase and decrease in direct response to changes in WOB_I. TPVC provides a large, PSV-like, pressure-assist when patient ventilatory demands are high, yet little or no pressure-assist when minute ventilatory demands are normal.[5,7,16] We believe that TPVC solves the previously mentioned conundrum: only patients exhibiting high ventilatory demands receive a pressure-assist and the amount of assist is continuously and automatically tailored to demand. We believe these features are exceptionally beneficial and recommend TPVC for all spontaneously breathing patients.[7] Others, however, disagree. They variously attribute TPVC's effects to "inadvertent pressure-assist"[16] or simply to PSV[17] and further contend that TPVC is not measurably different from an equivalent manually-set level of PSV[16,17] and, therefore, not needed. MacIntyre[18] recently took a provocative stance stating that TPVC (actually, he used the term TPT) may be more responsive than a comparable level of PSV. He further suggests that comparing TPVC to PSV[16,17] might be too simplistic and that TPVC deserves more study.[18]

Although it seems unlikely that a manually adjusted PSV level could duplicate the automaticity inherent with TPVC, we believe MacIntyre is correct; the question of equivalency between a manually-set level of PSV and TPVC remains, to date, unanswered.

We tested the hypothesis that ventilatory demands play an important role in determining the extent and magnitude of WOB_I. We also tested the hypothesis that TPVC and an equivalent manually-set level of PSV are different; and, that in response to patient effort, each produces a measurably different flow, pressure, and tidal volume.

Materials & Methods

Lung Model

A spontaneously-breathing patient was simulated using an in-vitro mechanical model, similar to that described by Katz et al.[19] This model uses a modified Michigan Instruments Model 2600 Training/Test Lung (TTL),* a 2-chambered, spring-and-bellows test lung. The device is modified by fastening a metal bar to one bellows of the TTL—when that particular lung, the driver side, is mechanically inflated, the bar lifts the contralateral lung, the 'patient' side. Lifting the patient-side bellows generates a subambient (or below-baseline) intralung pressure, thereby simulating spontaneous inhalation. The spontaneously breathing, patient side of the TTL is then attached to a second mechanical ventilator, which is monitored and tested as it provides assisted and unassisted spontaneous breaths.

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*Suppliers of commercial products are listed in the Product Sources section following the text.

The driver-side lung of the TTL was set to a compliance of approximately 0.04 L/cm H_2O and ventilated using a Hamilton Veolar ventilator. The patient-side lung was set to a compliance of 0.05 L/cm H_2O and ventilated using a modified Nellcor Puritan Bennett 7200ae ventilator (Fig. 1). The 7200ae ventilator was modified so that it could sense pressure at either the conventional site (inside the ventilator within the expiratory limb of the breathing circuit) or, by turning a 3-way stopcock, at the carinal end of the ETT. A disposable corrugated breathing circuit was connected to an 8.0-mm internal diameter (ID) ETT, a humidifier, and to the 7200ae ventilator. The humidifier was kept approximately half full to simulate average ICU conditions. The humidifier heat control remained off throughout the experiments.

The patient-side lung of the TTL was first attached to a variable-orifice flow sensor, followed by a 15-mm-ID plastic adapter modified to incorporate a tapered hole used as a pressure-sensing site (Fig. 1). Pressure signals obtained from the carinal sensing site within the 15-mm-ID adapter were transmitted via 3.175-mm-ID (1/8 in. ID) plastic tubing to a respiratory monitor and to the 3-way stopcock placed in the pressure-sensing apparatus of the 7200ae ventilator. The other end of the 15-mm-ID plastic adapter was attached to a model trachea, that was intubated with the ETT. For measuring airway pressure, a strip-chart recorder was attached via 3.175-mm-ID (1/8 in. ID) plastic tubing to the patient Y-adapter of the breathing circuit.

The driving ventilator for the model was set to deliver a continuous positive airway pressure (CPAP) of 5 cm H_2O and a sinusoidal inspiratory flow waveform. Inspiratory time was set at approximately 30% of the total respiratory cycle, which was in turn adjusted to 4 seconds, yielding a breathing frequency of 15 breaths/min.

The patient-side ventilator (7200ae) was adjusted to deliver a CPAP of 5 cm H_2O, at a sensitivity of −2 cm H_2O. Except where noted, these settings were maintained, regardless of mode, throughout the experiments. Ventilatory mode was varied as described in the experimental protocol.

Modeling Varying Patient Ventilatory Demands

WOB_I is mathematically defined as a function of the pressure drop (below-baseline pressure), measured at the carinal end of the ETT (P_{ETT}), and tidal volume (V_T):

$$WOB_I = \int P_{ETT} \cdot dV_T \qquad [2]$$

The respiratory monitor we used unfortunately does not directly measure WOB_I. Rather, the monitor measures and displays patient work of breathing, or WOB_{TOT}. To obtain accurate WOB_I values, the displayed work values were 'corrected' as explained in the Appendix.

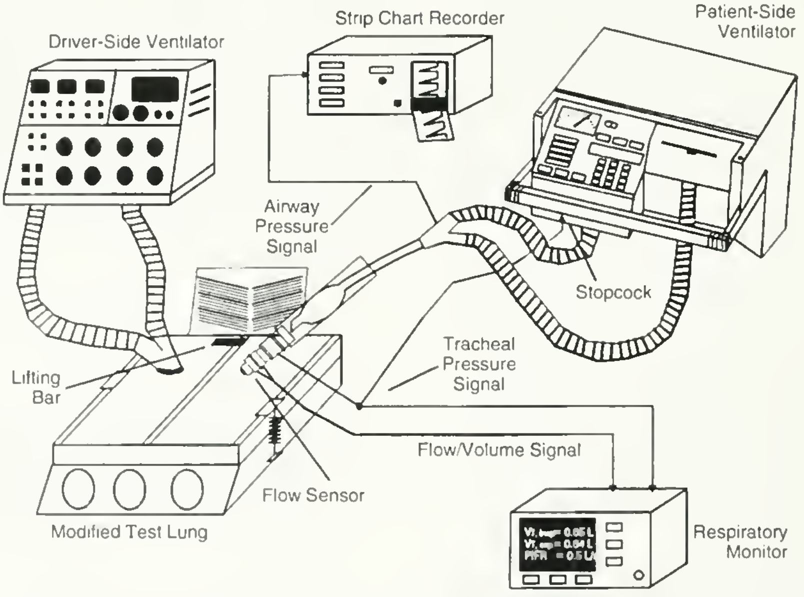

Fig. 1. The mechanical lung model with ancillary equipment used to simulate a spontaneously-breathing patient.

From Equation 2, it follows that changes in either P_{ETT}, V_T, or both result in variations in WOB_I. Spontaneous V_T changes in direct response to patient effort, whereas P_{ETT} changes for a number of reasons, not all controlled by the patient (for example, resistance of the ETT caused by changes in its caliber resulting from kinks or partial occlusion by mucus, variations in the patient peak inspiratory flow [PIFR] demand, and alterations in the selected ventilator sensitivity or cycling criteria). Because V_T and PIFR can be determined by the patient and change frequently, particularly in an ICU setting, they were varied during this study. Furthermore, these variables were covaried, as may occur in a clinical setting (when V_T varies, PIFR often concomitantly varies in the same direction). This covariance makes physiologic sense. WOB is better minimized by maintaining the duration of muscular effort and preserving a comfortable ratio of inspiratory-to-expiratory time (I:E).

Based on measurements taken directly from the in-line respiratory monitor, the V_T on the driving ventilator was progressively increased, producing V_Ts of 300 to 900 mL in 50-mL increments in the patient lung. By maintaining the inspiratory time at approximately 30% of the respiratory cycle, PIFR simultaneously and proportionally varied with increasing V_T. By matching the first V_T (300 mL) with a PIFR of 30 L/min, PIFR increased concomitantly with V_T (for each 50-mL increase in V_T, the PIFR increased approximately 5 L/min). In several instances when the selected V_T did not produce the desired PIFR, the inspiratory time control had to be slightly adjusted. This strategy yielded 13 different but clinically relevant combinations of V_T and PIFR. Using this methodology produced V_Ts that, when expressed in centiliters (cL) instead of mLs, corresponded exactly to PIFR, expressed in L/min (ie, 30 cL and 30 L/min, 35 cL and 35 L/min).

Ventilators are programmed to provide gas flow in response to patient demand. For a variety of reasons, this flow may be more or less than that demanded by the patient. To ensure that each of the 13 patient-demanded V_T and PIFR test combinations were completely independent of the flow and volume demands produced by the patient ventilator, the driving ventilator was adjusted only after disconnecting the patient ventilator from the simulated patient. After reconnecting the patient ventilator and ETT, measurements of the ventilator's response in each tested mode under each of the 13 patient ventilatory demands were made.

Evaluation Methods

Experiment 1: Protocol for Measuring WOB_I. We varied V_T and PIFR as described and measured WOB_I (see Appendix) during spontaneous CPAP set at 5 cm H_2O, PSV set at 5 cm H_2O (PSV_5), and with TPVC. To accomplish this, the P_{ETT} and flow signals sensed at the patient side of the TTL were directed into the respiratory monitor (Fig. 1). Data from at least 5 individual breaths were recorded during each of the 3 modes at each of the 13 tested combinations.

Experiment 2: Protocol for Comparing TPVC and an Equivalent Level of PSV. As in Experiment 1, the 13 combinations of V_T and PIFR were adjusted in sequence. Beginning with the first V_T and PIFR combination (30 cL [300 mL] and 30 L/min), the ventilator was set to deliver TPVC. Data on PIFR, airway pressure, V_T, and WOB_I for a minimum of 5 individual TPVC breaths were recorded directly from the respiratory and pressure monitors.

The pressure-sensing apparatus within the ventilator was then switched to sense pressure at the conventional site, and the ventilator was set to provide PSV. An equivalent level of PSV was adjusted by increasing the PSV level until the measured WOB_I was as close as possible to the average measured during the preceding TPVC run. Data were again recorded for PIFR, airway pressure, V_T, and WOB_I, for a minimum of 5 individual breaths.

Following completion of data collection during the equivalent level of PSV run, the PSV mode was turned off, the pressure-sensing apparatus returned to the TPVC configuration, the ventilator circuit disconnected, and the next V_T and PIFR combination adjusted. Each of the aforementioned steps were repeated, including readjustment of the equivalent level of PSV, until each of the 13 V_T and PIFR combinations had been tested.

All instruments used during the experiment were calibrated and operated according to manufacturers' specifications. Calibration was verified using a 3-liter calibration syringe and a calibration analyzer.

After completing the two experiments, the 7200ae was compared to a Bird 8400STi. For this comparison, the model was adjusted to a V_T of 60 cL (600 mL) and a PIFR of 60 L/min. CPAP was reduced to zero on both the driver and patient ventilators, but sensitivity remained at −2 cm H_2O. Finally, the exhalation valve housing on the 8400STi was modified so that the pressure-sensing site could be easily switched between the conventional and the carinal site (as was done on the 7200ae) by turning a stopcock. Real-time flow, pressure, and volume tracings were made, and WOB_I was measured with each of the 2 ventilators, under 3 separate conditions: (1) spontaneous breathing, (2) TPVC, and (3) at a PSV level equivalent to TPVC (determined in Experiment 2 as approximately 7 cm H_2O).

Statistical Analysis

Data for WOB_I, PIFR, peak airway pressure, and V_T, from each set of 13 V_T and PIFR combinations in the 2 experiments, were averaged and standard deviations (SD) calculated. Data comparing the dependent variable, WOB_I, between the different modes tested in Experiment 1 were analyzed at each V_T and PIFR combination using a 1-factor analysis of variance. Multiple comparisons were analyzed using the Tukey HSD method. Data comparing the dependent variables: PIFR, peak airway pressure, and V_T between TPVC and an equivalent level of PSV obtained at each different V_T and PIFR combination, were analyzed using unpaired *t* tests. Statistical significance would be established at $\alpha = 0.05$.

All averaged data were plotted, and to mathematically model and visually demonstrate trends, least-squares linear or polynomial regression equations were fitted to corresponding data.

Results

In Experiment 1, regardless of the inspiratory flow and volume demands, measured WOB_I was greatest during CPAP, less during PSV_5, and least during TPVC (Fig. 2). Furthermore, in direct response to simulated increasing inspiratory demands, CPAP demonstrated a significantly larger increase in WOB_I. When compared to PSV_5, CPAP increased WOB_I by 10% (0.98 vs 0.89 J/L), and, when compared to TPVC, by 490% (0.98 vs 0.20 J/L). Data for CPAP were statistically different from those during PSV_5 and TPVC at all tested levels of PIFR and V_T. TPVC and PSV_5 were essentially the same up to a PIFR of 40 L/min but statistically different at all other levels thereafter.

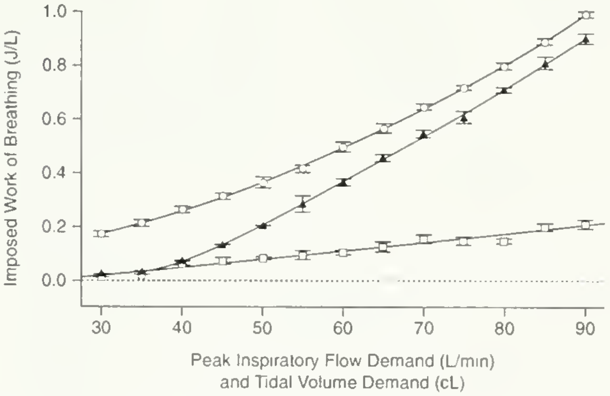

Fig. 2. Work imposed by the breathing apparatus measured in joules per liter (J/L) of ventilation during continuous positive airway pressure (CPAP) (open circles), pressure support ventilation (PSV) set at a level of 5 cm H_2O (solid triangles), and tracheal pressure ventilator control (TPVC) (open squares) plotted against peak inspiratory flow demand (L/min) and tidal-volume demand (cL). Data are mean (SD). Note that with TPVC only, imposed work of breathing was essentially zero at all inspiratory demands. cL = centiliter, or L/10.

In Experiment 2 under most conditions, measured PIFR was significantly greater during TPVC than during an equivalent manually-set level of PSV. For instance, at a PIFR demand of 90 L/min, TPVC supplied approximately 23% (118 vs 96 L/min) more flow in direct response to demand. There were two exceptions: PIFR demands of 30 and 35 L/min. At 30 L/min, the measured PIFR was greater during an equivalent level of PSV, and there was no difference at a PIFR demand of 35 L/min (Fig. 3). TPVC produced a variable effect on the eventual peak airway pressure (Fig. 4). As a result, at PIFR demands < 45 L/min and > 70 L/min, the measured peak airway pressure during TPVC was significantly greater than during an equivalent level of PSV. At PIFR demands of 45 and 70 L/min, peak airway pressure was not different, and, between 45 and 70 L/min, peak airway pressure was greater during an equivalent level of PSV. In terms of measured V_T, under every tested combination of PIFR and V_T, an equivalent level of PSV produced a significantly higher measured V_T (Fig. 5). At a V_T demand of 90 cL (900 mL) and 90 L/min for example, the manually adjusted, equivalent level of PSV overinflated the lung model by 14%, compared to 8% during TPVC (1030 vs 972 mL).

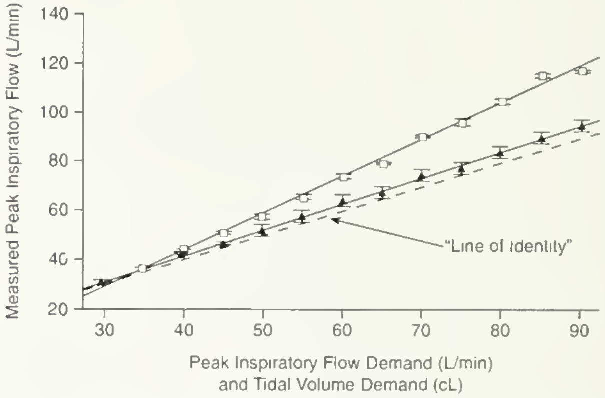

Fig. 3. Measured peak inspiratory flow (L/min) for tracheal pressure ventilator control (TPVC) (open squares) and an equivalent manually-set level of pressure support ventilation (one producing the same measured imposed work of breathing as TPVC) (solid triangles) plotted against peak inspiratory flow (L/min) and tidal volume demands (cL). The line of identity represents a measured peak inspiratory flow equal to that demanded by the spontaneously-breathing model without influence of the mechanical ventilator. Data are mean (SD). cL = centiliter, or L/10.

The relationship between the PIFR and V_T demands and the level of PSV manually set by the clinician required to equal the work-sparing effect of TPVC at that demand (Fig. 6) was best characterized by a linear model. For example, PSV set at approximately 7 cm H_2O is required at a PIFR demand of 60 L/min and PSV set at 14 cm H_2O is required at a PIFR demand of 90 L/min to decrease WOB_I to that observed during TPVC.

To compare applied pressure during a TPVC breath to an equivalent, manually-set level of PSV breath, under conditions of a PIFR of 90 L/min and V_T of 90 cL (900 mL), a sampling of 40 equally-spaced (1 each 100 ms) individual points were taken from the real-time plots of airway pressure. Data were then overlaid, producing a composite graph combining

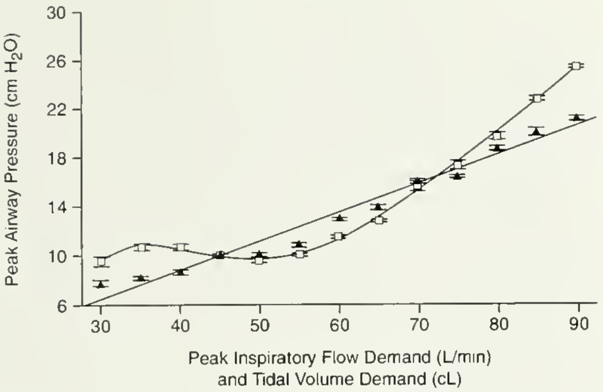

Fig. 4. Measured peak airway pressure (cm H_2O) during tracheal pressure ventilator control (TPVC) (open squares) and an equivalent manually-set level of pressure support ventilation (PSV) (one producing the same measured imposed work of breathing as TPVC) (solid triangles), plotted against peak inspiratory flow demand (L/min) and tidal volume (cL). Data are mean (SD). cL = centiliter, or L/10.

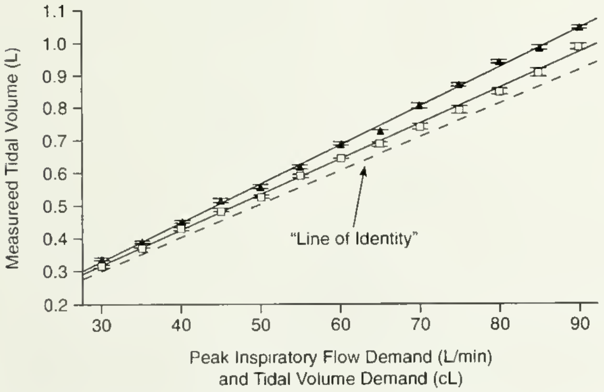

Fig. 5. Measured tidal volume (L) during tracheal pressure ventilator control (TPVC) (open squares) and an equivalent manually-set level of pressure support ventilation (PSV) (one producing the same measured imposed work of breathing) (solid triangles), plotted against peak inspiratory flow (PIFR) demand (L/min) and tidal volume (cL). The line of identity represents a measured V_T equal to that demanded by the spontaneously-breathing model without influence of the mechanical ventilator. Data are mean (SD). cL = centiliter, or L/10.

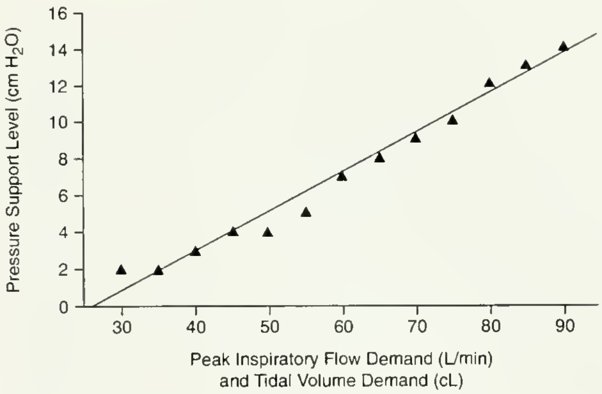

Fig. 6. The level of pressure support ventilation (cm H_2O) required to reduce measured imposed work of breathing to that measured during tracheal pressure ventilator control under the same conditions, plotted against peak inspiratory flow demand (L/min) and tidal volume demand. cL = centiliter, or L/10.

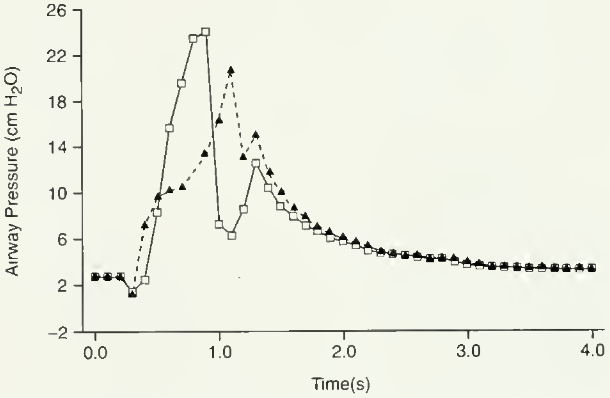

Fig. 7. Airway pressure (cm H_2O), during tracheal pressure ventilator control (TPVC) (open squares) and an equivalent manually-set level of pressure support ventilation (PSV) (14 cm H_2O, ie, one producing the same measured imposed work of breathing) (solid triangles), plotted against time. The representative breaths occurred in response to simulated conditions of a peak inspiratory flow demand of 90 L/min and a tidal volume of 90 cL (900 mL). Note that by mid-inhalation during TPVC, airway pressure is substantially higher (≈23 cm H_2O) compared to PSV (≈10 cm H_2O). The higher pressure generated is in response to higher ventilator delivered flow provided early in the breath.

representative breaths from the TPVC and corresponding equivalent level of PSV runs (Fig. 7).

Finally, to compare and contrast the response of two different mechanical ventilators during TPVC and then during equivalent levels of PSV, real-time plots for inspiratory flow, tidal volume, and P_{ETT} were plotted side-by-side (Fig. 8, top panels). Pressure-volume loops for each of the tested conditions were also similarly plotted (Fig. 8A, B, C).

Discussion

At the first Nagoya Conference, participants agreed the ideal type of PSV or pressure-assist should respond not only to the patient trigger but should also provide an inspiratory flow and a V_T that are synchronous with the muscle contraction pattern.[4] We believe that our data provide the first evidence that TPVC better meets these goals than an equivalent, manually-set level of PSV. Under every tested condition, TPVC provided significantly higher PIFRs (Fig. 3) and V_Ts much closer to that demanded by the patient (Fig. 4). More importantly, as MacIntyre recently predicted,[18] TPVC was far more responsive and matched ventilator-supplied flow to patient-demanded flow better than an equivalent level of PSV (Fig. 7). Also note in Figure 7 that during TPVC, a significantly higher airway pressure is generated early in the breath (approximately 23 cm H_2O) compared to the manually-set, equiv-

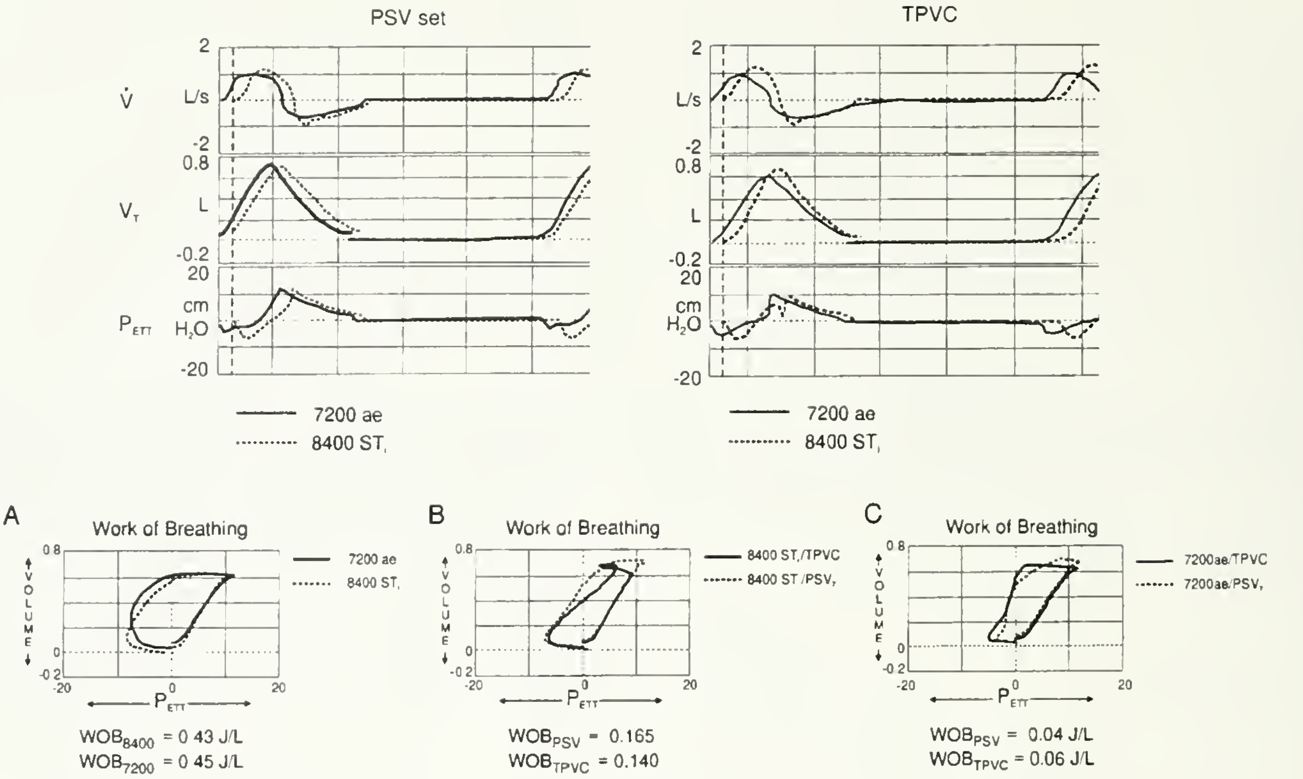

Fig. 8. Real-time recordings of flow ($\dot{V}$), tidal volume (V_T), and endotracheal tube pressure (P_{ETT}) from the carinal end of an 8.0-mm internal diameter ETT shown for a preset level of pressure support ventilation (PSV_{set}) (top left), tracheal pressure ventilator control (TPVC) (top right), and imposed work of breathing (WOB_I) (Panels A, B, & C). In the panel labeled PSV_{set}, a simulated patient breathes spontaneously at a peak inspiratory flow demand of 60 L/min and a V_T of 60 cL (600 mL), first connected to a 7200ae (solid line) and then connected to an 8400STi (dashed line) ventilator (PSV_{set} = 7 cm H_2O and zero end-expiratory pressure). In the panel labeled TPVC, the same simulated patient is first ventilated with a 7200ae modified to provide TPVC at zero end-expiratory pressure (solid line), and then with a 8400STi similarly modified and adjusted (dashed line). Although differences are present, both ventilators respond with a pressure-assist when modified to provide TPVC. In Panel A (bottom), the area located below (to the left) the baseline pressure (in this case, zero end-expiratory pressure) within the pressure-volume loops depict WOB_I of a simulated spontaneously breathing patient connected to a 7200ae (solid line) and an 8400STi ventilator (dashed line) (the larger the area contained to the left of baseline pressure within the loop, the greater WOB_I and vice versa). Both ventilators were set at zero end-expiratory pressure. In Panel B (bottom), the same simulated patient first breathed from an 8400STi providing PSV_{set} at 7 cm H_2O and zero end-expiratory pressure (dashed line), and then from the same 8400 STi modified to provide TPVC (solid line). In Panel C (bottom), the same simulated patient breathed from a 7200ae providing PSV_{set} at 7 cm H_2O and zero end-expiratory pressure (dashed line), and then from the same 7200ae modified to provide TPVC (solid line). Note that the area to the left of the baseline pressure with both the 7200ae and the 8400STi represents a decreased WOB_I (Panels B, C) when compared to spontaneous breathing at zero end-expiratory pressure (Panel A). Also note that the 7200ae appears slightly more effective in reducing WOB_I than the 8400STi in both the PSV and TPVC modes.

alent level of PSV (approximately 10 cm H_2O). We believe that matching patient demand for flow to ventilator supply of flow early in the breath promotes patient-ventilator synchrony and minimizes work of breathing.

PSV, characterized by a rapid rise to pressure and an immediate termination of pressure at the end of spontaneous effort, was also advocated at the Nagoya Conference.[4] Figure 7 clearly demonstrates that when compared to TPVC, an equivalent manually-set level of PSV falls markedly short of these goals. From the onset of the breath, the conventionally applied PSV breath fails to respond to increasing patient demand. By mid-inhalation, there is evidence of flow starvation during the PSV breath. That is, because patient flow demand exceeds the ventilator flow supply, the airway pressure waveform appears 'scooped-out' (Fig. 7), instead of exhibiting the square pattern normally associated with PSV. Only when respiratory effort diminishes, near the end of spontaneous effort, is the pressure applied during the PSV breath able to attain the selected PSV level (14 cm H_2O). Notice that this failure to respond with sufficient flow to meet demand causes the ventilator to overshoot the set PSV level by approximately 50% (21 vs 14 cm H_2O). Yet, at precisely the same moment, pressure and flow applied during the TPVC breath have returned to essentially baseline CPAP levels. For this model, TPVC is clearly more responsive than a comparable level of PSV. Improved responsiveness not only serves to reduce

WOB_I and improve patient-ventilator synchrony, but, just as importantly, eliminates potential delays in terminating breaths (cycling). Delayed cycling retards exhalation, which in turn, predisposes to adverse cardiovascular effects and gas trapping (auto-PEEP). Also, it is interesting to note the second pressure peak in both the TPVC and PSV airway pressure waveforms (Fig. 7). These peaks occur during exhalation and should not be construed as being related to TPVC. As exhalation proceeds, airway pressure assumes a value equal to the baseline level (CPAP) plus the pressure drop produced as exhaled gases pass through the resistant exhalation valve (pressure = resistance × flow). If the sum of these 2 pressures is higher than airway pressure at the onset of exhalation, a second peak occurs. During TPVC, the second pressure peak is noticeably lower than that recorded during the equivalent PSV breath. A lower V_T during TPVC (Fig. 5) is partially responsible (because the resultant peak expiratory flow is lower), and also the breath was terminated more synchronously with the onset of exhalation.

Some might argue that the delayed rise to pressure experienced during the equivalent level of PSV breath (Fig. 7) could be manually increased by using a ventilator control designed specifically for this purpose. Some newer models of mechanical ventilators incorporate this feature or offer it as an option (eg, Bear 1000). Unfortunately, we could not investigate this possibility because our 7200ae was not so equipped. Nevertheless, the question is a reasonable one and warrants study at some later date.

We do not believe TPVC represents an entirely new mode of ventilation. Rather, TPVC simply describes the way a ventilator provides spontaneous gas flow when the pressure-sensing-control site is located at the carinal end of the ETT. Thus, the behavior of the ventilator during TPVC may relate more to the tested ventilator's individual algorithm for providing spontaneous gas flow than to a new set of rules that apply equally to all mechanical ventilators. Nevertheless, virtually all modern mechanical ventilators are programmed similarly (to minimize the additional WOB imposed by the breathing circuit and ventilator), thus it is unlikely the TPVC effect represents an idiosyncrasy peculiar to only one brand of ventilator. In fact, we have observed and reported similar behavior with several other brands of ventilators.[5] To further illustrate this fact, Figure 8 depicts flow, volume, pressure, and work-sparing effects (in real-time) of 2 different ventilator brands, during both conventional PSV (an equivalent level) and TPVC. Notice that both ventilators behave comparably under both conditions. The slight differences can best be attributed to either software or hardware differences between ventilators. For instance, whether set for PSV or TPVC, the 8400STi is less responsive than the 7200ae, as evidenced by a larger drop in airway pressure during both modes (Fig. 8, top panels: PSV_{set} and TPVC). The smaller reduction in pressure with the 7200ae translates to a reduced WOB during both PSV and TPVC (Fig. 8A vs 8B). When compared to the 7200ae, the 8400STi actually provides a higher peak inspiratory gas flow in both PSV and TPVC (Fig. 8, top panels), yet it imposes more work under both conditions (Fig. 8B, 8C). This is contrary to the popular perception that higher inspiratory flows always reduce WOB_I. This phenomenon underscores behavior typical of the unresponsive ventilator; that is to provide more flow or pressure (see pressure overshoot in Figure 7 and related discussion) than is actually required, but at a point too late during the course of inspiration to meet the patient's demands. Furthermore, by comparing Panel A (Fig. 8) to Panels C and D (Fig. 8), we can see that while TPVC effectively reduces WOB_I with both ventilators, it does not correct a lack of responsiveness or other deficiencies inherent to the design of individual ventilators. In this case, the 8400STi's apparent lack of responsiveness imposes slightly more work, whether it is set to provide a conventional PSV breath or modified to provide TPVC.

Another important fact should not be overlooked. TPVC works with or without CPAP (Fig. 8); for this illustration, both ventilators were set to provide zero CPAP, yet the work-reducing effect of TPVC is clearly evident when Panel A (Fig. 8) is compared to Panels B and C (Fig. 8).

Arguably the most important and yet least frequently discussed advantage of TPVC is its automaticity (automatic and variable levels of pressure-assist in response to patient inspiratory demand). But why is this facet so important? Clinicians recognized some time ago that most patients tolerate fixed, partial airway obstruction, such as that imposed by the ETT, ventilator, and breathing apparatus.[13,14] If this were not so, how were so many patients successfully weaned from mechanical ventilatory support before the advent of PSV? What is not clearly understood is how quickly WOB_I can become a problem for any patient who increases his or her ventilatory demands. The three regression lines (Fig. 2) model changing imposed workloads in response to varying patient demands. The largest changes occur during CPAP (highest line), followed by PSV set at 5 cm H_2O (middle line), and the smallest changes accompanied TPVC (lowest line). This figure depicts the disadvantage intrinsic to selecting a fixed, compensatory level of PSV (in this example, 5 cm H_2O). Clearly, this strategy reduces WOB_I with modest respiratory efforts, yet it may not provide enough support to make a clinical difference when ventilatory demands are high. Selecting a higher level of PSV (not shown) reduces WOB_I at higher ventilatory demands but risks respiratory muscle atrophy[15] when demand diminishes. TPVC, in contrast, provides an automatic pressure-assist directly proportional to demand. At high ventilatory demands, the PSV level required to equal the TPVC effect was 14 cm H_2O, at the lowest, 2 cm H_2O (Fig. 6). It is interesting to note that this range of PSV levels nearly matches patient data previously published on the subject. For instance, in a series of 11 adult and 4 pediatric patients, the mean (SD) PSV required to overcome WOB_I was 13.5(4.8) cm H_2O.[10] Brochard et al[6] reported similar findings. In a group of 5 patients with COPD and another 6 who were free of intrinsic lung disease, the compensatory level of PSV was 12(2) cm H_2O for those with COPD and 5.7(1.5) cm H_2O for those free of lung disease.[6] However, these measurements were 'snapshots' made at a specific point in time. If any of the studied patients acutely or gradually altered their ventilatory demands, the compensatory level of PSV would have to be altered accordingly, either up or down.

Although any number of ventilatory techniques may temporarily reduce WOB_I, none shares the ability to raise or lower support in direct response to patient need. Unstable or labile patients may change ventilatory demands repeatedly, and, because current ventilatory modes require manual adjustments, the burden of selecting and maintaining an appropriate support level is placed on the clinician. With recent reports describing WOB_I masquerading as ventilator weaning intolerance[9] and patients exhibiting abnormally high WOB_{TOT} values prior to successful extubation,[20] it is becoming evident that even experienced clinicians may not be up to this task.

The concept of an automatically adjusting pressure-assist level is neither new nor unique to TPVC. Proportional-assist ventilation (PAV)[21,22] accomplishes a similar effect, albeit by a different approach. There are advantages and disadvantages intrinsic to both techniques; the major differences are worth mentioning. PAV requires that the clinician first make an accurate measurement of respiratory system resistance and compliance. The ventilator then uses this information and real-time flow, volume, and pressure signals to calculate and adjust the necessary pressure-assist level breath-to-breath. Because PAV is based upon the total respiratory system compliance and resistance, it simultaneously manages both imposed and physiologic workloads. During TPVC, the ventilator simply attempts to maintain a pressure close to the set CPAP level (even when CPAP is 0) at the carinal end of the ETT. With high inspiratory flow demands, the presence of the ETT between the ventilator and the patient produces a large pressure drop at the carina. The TPVC ventilator responds by increasing flow and pressure, which appears as a pressure support effect at the Y-piece of the breathing circuit (but not at the carina or in the lungs). When the pressure drop at the carina has been neutralized, the ventilator simply reduces the flow and pressure, keeping carinal pressure in the desired range. Because the pressure drop that occurs at the carina is secondary to WOB_I, TPVC manages only the imposed workload.

Based on these and previously published data,[5,7,12,16] TPVC offers the promise of facilitating the management of WOB_I. Despite its potential, TPVC cannot and will not function reliably without accurate and dependable pressure signals obtained from the hostile environment at the carinal end of the ETT. Investigators experimenting with TPVC have been using air-filled catheters either embedded in the side wall of the ETT or passed through the lumen of the ETT. Certainly, such catheters are simple, but they are also prone to occlusion by secretions, kinks, and other mechanical obstructions.[17] Although these drawbacks are formidable, they are not insurmountable. For instance, by using a periodic high-pressure flushing system and protective algorithms, the Bunnell Life Pulse Neonatal Jet Ventilator has successfully monitored P_{ETT} (from an embedded catheter) and from that signal safely controlled the internal drive pressure of the jet pulses. (In theory, this is nearly identical to the process required for TPVC). It is also possible to measure tracheal pressures with either a stand-alone or embedded fiberoptic catheter and miniature pressure transducer. We have tested a prototype of such a system and found it both accurate and precise.[23] A safe and reliable TPVC system will undoubtedly involve developmental costs; whether the advantages of TPVC will eventually justify these costs remains to be proven.

Conclusion

In conclusion, our findings reveal a strong and direct relationship between patient ventilatory demands and WOB_I. It follows that any manually-selected level of PSV is not always appropriate because when a patient's inspiratory demands increase the level of PSV required to overcome WOB_I concomitantly increases, and vice versa. These data provide evidence that TPVC overcomes this dilemma by providing a continuously variable pressure-assist, the magnitude of which bears a direct relationship to the patient's ventilatory demands. Thus, TPVC is far more complex than a simple system for "overcoming endotracheal tube resistance."[17] Rather, in an in-vitro spontaneously-breathing model, TPVC provides a measurably superior form of pressure-assist. When compared to a manually-set, equivalent level of PSV, TPVC provided significantly higher inspiratory flows in close synchrony with demand, V_Ts closer to that demanded, a more rapid and responsive rise to pressure, and a more synchronous termination of the applied pressure. Furthermore, unlike PSV, TPVC automatically adjusts the level of pressure-assist provided to meet changing ventilatory demands. If these differences can be substantiated in spontaneously-breathing ventilated patients, and a safe and reliable system for measuring P_{ETT} developed, the first ventilator offering an optimized version of TPVC will improve the interaction between the patient and breathing apparatus.

PRODUCT SOURCES

Ventilators:

Hamilton Veolar Ventilator, Hamilton Medical Inc, Reno NV
Nellcor Puritan Bennett 7200ae Ventilator, Nellcor Puritan Bennett Corporation, Carlsbad CA
Bird 8400STi Ventilator, Bird Products Corporation, Palm Springs CA

Lung Model:

Model 2600 Training/Test Lung, Michigan Instruments Inc, Grand Rapids MI

Endotracheal Tube & Trachea Model:
Endotracheal Tube, Mallinckrodt, Hazelwood MD
Imatrach, Mallinckrodt, Hazelwood MD

Monitoring & Calibration Equipment:
Bicore CP-100 Monitor, Allied Medical Products, Riverside CA
Bicore VarFlex Flow Adult Transducer, Allied Medical Products, Riverside CA
Pneumogard 1200A Monitor, Novametrix Inc, Wallingford CT
RT-200 Calibration Analyzer, Allied Medical Products, St Louis MO
Collins 3-Liter Calibration Syringe, W E Collins, Braintree MA

Humidifier & Plastic Adapters:
ConchaTherm III—Model 380-80R, Hudson-RCI Inc, Arlington Heights IL
15-mm-ID—Catalog Number: 1422, Hudson-RCI, Arlington Heights IL
Three-way stopcock—Catalog Number: K75, Baxter Healthcare Corp, Valencia CA

Breathing Circuit:
Breathing circuit—Catalog Number: 5615, Kendall Medical Products Inc, Greenwood SC

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APPENDIX
Determining WOB_I from a WOB_{TOT} Value Provided by the Bicore CP-100 Respiratory Monitor

Proper measurement and calculation of WOB_{TOT} requires a pneumotachograph (positioned to measure inspiratory and expiratory gas flow), an esophageal catheter (to obtain esophageal pressure [P_{es}]—as a surrogate for pleural pressure), and knowledge of patient chest-wall compliance (C_{CW}). To begin the calculation of work, the monitor plots the change in P_{es} with respect to the change in V_T, creating a pressure-volume (P-V) loop. The area circumscribed by the P-V loop represents the resistive and elastic work required to inflate the lungs, but fails to account for all of the elastic work required to expand the entire respiratory system. To complete the calculation (and account for the missing elastic work), the monitor uses the programmed C_{CW} and measured V_T to compute an approximation of missing elastic work and, in turn, adds this value to the work measured within the P-V loop. Mathematically, WOB_{TOT} including the approximation is expressed[1]

$$WOB_{TOT} = \int P_{es} \cdot dV_T + \frac{(V_T^2)}{2(C_{CW})}.$$

To save the operator time and to avoid a tedious and difficult measurement of C_{CW}, the monitor defaults to (assumes) a normal C_{CW} (200 mL/cm H_2O), unless the operator specifically measures C_{CW} (using another program contained within the monitor) and programs that measured value into the monitor's memory. In either case, the monitor uses signals from its pressure and flow sensors, and the C_{CW} residing in memory to solve the equation, ultimately displaying patient WOB, or WOB_{TOT}.

If an operator attempts to measure WOB_I by simply substituting a P_{ETT} signal for the normal P_{es} signal,[2,3] the monitor computes and displays a falsely elevated value because the computer automatically adds the approximation factor for the elastic work unaccounted for within a traditional P-V loop (WOB_I does not include any elastic work to inflate the respiratory system and would be measured by determining the area below the baseline pressure, but within the associated P-V loop only). Under most conditions, this error is small and probably not clinically important. For instance, when C_{CW} is normal, the elastic work required to inflate the respiratory system accounts for only about 10% of the normal WOB_{TOT}, or approximately 0.06 J/L for every 500 mL of V_T. The magnitude of error, however, varies inversely with C_{CW}. That is, if C_{CW} is measured and entered into the monitor's memory at a value half that of normal (100 mL/cm H_2O), the elastic work to expand the respiratory system doubles (ie, 0.12 J/L for every 500 mL of V_T). To obtain accurate WOB_I values for the purposes of this study,[4] the correction factor (elastic work required to inflate the respiratory system) was first computed by hand (based on each measured V_T and a normal C_{CW}) and, then, was subtracted from the displayed value for WOB_{TOT}. Stated mathematically:

$$WOB_I = WOB_{TOT} - \frac{(V_T^2)}{2(C_{CW})}.$$

For example:

While using the respiratory monitor to measure WOB_I, the following measurements were displayed following a particular spontaneous inhalation: $WOB_{TOT} = 0.45$ J/L, $V_T = 500$ mL, and $C_{CW} = 200$ mL/cm H_2O (the default value). The correction factor (unaccounted for elastic work)

$$= \frac{V_T^2}{2(C_{CW})},$$

$$= \frac{(500\ \text{mL})^2}{2} \cdot \frac{\text{cm } H_2O}{200\ \text{mL}},$$

$$= 500^2\ \text{mL}^2/400\ \text{mL/cm } H_2O,$$

$$= 250{,}000\ \text{mL}^2/400\ \text{mL/cm } H_2O,$$

$$= 625\ \text{mL} \cdot \text{cm } H_2O.$$

We now convert using the factor 1 mL · cm $H_2O = 10^{-5}$ kg · m

$$= (625\ \text{mL} \cdot \text{cm } H_2O)\left(\frac{10^{-5}\ \text{kg} \cdot \text{m}}{\text{mL} \cdot \text{cm } H_2O}\right),$$

$$= 625 \cdot 10^{-5}\ \text{Kg} \cdot \text{m}.$$

Converting again, with factor: 1 kg · m = 9.81 J

$$= (625 \cdot 10^{-5}\ \text{kg} \cdot \text{m})\left(\frac{9.81\ \text{J}}{\text{kg} \cdot \text{m}}\right),$$

$$= 6131 \cdot 10^{-5}\ \text{J},$$

$$= 0.06\ \text{J}.$$

Because the displayed work value includes this quantity, we must remove it (using the first equation of the Appendix) to obtain the actual WOB_I performed by the patient:

$$WOB_I = WOB_{TOT} - \frac{(V_T^2)}{2 \cdot C_{CW}}.$$

$$WOB_I = 0.45 - 0.06 \text{ J/L}.$$

$$WOB_I = 0.39 \text{ J/L}.$$

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Heliox in the Treatment of Airflow Obstruction: A Critical Review of the Literature

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Anne Pohlman RN MSN, and Jesse B Hall MD

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Introduction

The use of helium (He)-oxygen (O_2) mixtures, or heliox, as a medical therapy was proposed as early as 1934 by Barach, who first observed that breathing heliox appeared to relieve dyspnea in patients with severe asthma and upper airway obstruction.[1-4] In 1955, Schiller et al[5] were unable to demonstrate significant physiologic improvement in severe asthmatics who breathed heliox. In 1959, Grape et al[6] described decreased respiratory resistance with no changes in lung volumes when heliox was breathed by patients with emphysema. Given this sparse and conflicting evidence of utility, it is not surprising that heliox did not achieve wide, early application. However, more recent clinical reports and trials have suggested a benefit in selected patients.

Theoretical Foundations

Helium is an inert gas one eighth the density of nitrogen. When blended with 21% oxygen, the resulting gas mixture has a threefold reduction in density compared to air and reduces the pressure gradient associated with gas flow through airways with non-laminar flow. In normal human airways, the resistive pressure drop between the glottis and tenth generation airways varies with the density of inspired gas because flow is disturbed by bronchial branch points leading to tur-

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bulent flow. The resistive pressure drop over the tenth to twentieth generations is density-independent because flow in these regions is laminar.[7] Because 80% of the inspiratory resistive pressure drop occurs in the more proximal density-dependent segments, breathing heliox reduces airways resistance (R_{aw}) to 28-49% of that measured with air even in normal subjects.[8,9] However, because R_{aw} during air breathing is normally less than 3 cm $H_2O \cdot L \cdot s^{-1}$, this 40% pressure reduction with heliox has little importance in normal subjects. During bronchospasm and upper airway obstruction, R_{aw} can increase to 30-50 cm $H_2O \cdot L \cdot s^{-1}$, with much of this increase related to turbulent (non-laminar) flow in the first to the tenth airway generations. Because heliox is most likely to improve non-laminar flow in these airways, both asthma and upper airway obstruction are expected to be responsive to heliox breathing.

It is interesting to note that the use of heliox in these clinical circumstances is not for treating the underlying disease or for influencing the anatomy of the airway. Rather, heliox is used to reduce resistance of the airways and to reduce respiratory muscle work until definitive therapies (pharmacologic and/or surgical treatment of upper airway obstruction or pharmacologic treatment of asthma) act to reduce airway resistance and eliminate the need for heliox breathing.

To be effective in reducing airway resistance, concentrations of helium must be high, ideally above 70% of the inhaled gas mixture. This of course limits the amount of oxygen that can be administered simultaneously. The hypoxemia associated with airway disease is modest and responsive to oxygen therapy[10,11] because the underlying mechanism of gas-exchange impairment is ventilation-perfusion mismatch.[12]

Heliox might also be useful as a vehicle for nebulizing aerosolized medications. Because heliox reduces turbulent-flow in upper airways, and turbulence is responsible, in part, for premature aerosol deposition in airway appliances (eg, the endotracheal tube) or the native upper airways, aerosols nebulized in heliox should be delivered with greater efficiency to smaller airways. In asthma, in particular, increased resistance occurring in the third through tenth airway generations could result in ineffective aerosol deposition in the upper airway that could be reduced with the use of heliox delivery systems.

Clinical Applications—Experience with Heliox since 1970

Upper Airway Obstruction

The use of heliox to reduce airway resistance in adults with upper airway obstruction has been reported in several anecdotal series[3,13-16] and has become one of the more accepted indications for heliox use. Most of these reports present cases in which heliox was administered to patients with anatomic or functional obstruction of the upper airways and whose respiratory distress improved, averting the need for intubation. As with any noncontrolled study, the observed improvement may have resulted from improvement in the underlying process and/or the effects of other simultaneous therapies. However, the rapid improvement seen in these reports, usually manifested within several minutes and reversed when heliox was discontinued even briefly, may suggest an independent beneficial effect of the gas related to its physical properties.

Upper airway diseases in children have also been treated with heliox. Barach[2] suggested heliox use for "children in whom inflammatory swelling of the larynx and trachea, due to infection, foreign body or instrumentation is frequent." Duncan[17] demonstrated marked improvement of subjective variables (breath sounds, degree of stridor, cough, retractions, and cyanosis) in 7 of 7 infants with croup or laryngotracheobronchitis. Nelson and McClellan[18] examined the effects of different He-O_2 ratios, specifically 70:30 to 80:20, in 14 infants with severe refractory croup. They stated, "All patients were observed to be in less distress immediately. The cough, while still barky, was not distressing. Flaring of nostrils, sternal retractions, and use of accessory muscles of respiration were improved. In 11 of 14 patients, comments on the charts indicated sleep or a restful state and great improvement from their previous condition. In no instance did a patient deteriorate."[18] Wolfson et al[19] examined the mechanics and energetics of breathing in 12 preterm infants with bronchopulmonary dysplasia. Esophageal pressures that index respiratory muscle work decreased by 28% with heliox as opposed to air. Heliox has also been used in children with mediastinal pathology and other mass lesions causing upper airway obstruction.[20,21]

Kemper et al[22] reported the case of a 7-year-old girl who, during recovery from burns, experienced postextubation stridor that responded to 70:30 heliox. In a double-blind, randomized, controlled, crossover trial,[23] 13 children with postextubation stridor breathed heliox versus oxygen-enriched air. Subjects experienced a 38% reduction in respiratory distress score during heliox breathing. Respiratory distress was not significantly affected while breathing oxygen-enriched air.

Asthma

Animal Studies. A number of studies have examined the effect of heliox breathing in both intact animals and excised animal or human lungs. To summarize this literature, heliox reduces lower airway resistance[7] and increases expiratory flow.[24]

Human Studies. Several anecdotal case studies have suggested that heliox may reduce P_{aCO_2} in patients with hypercapnic exacerbations of asthma.[25-27] Shiue and Gluck[25] administered heliox (60:40 to 75:25) to 10 spontaneously breathing patients with status asthmaticus and respiratory acidosis. In 9 of the 10 patients, P_{aCO_2} decreased, and pH increased accordingly after 20 minutes of heliox breathing. After 1 hour, all 10 patients experienced increased pH, from a mean of 7.26

to 7.37, and mean P_{aCO_2} decreased from 56 to 40 torr. Kass et al[27] studied 12 patients with acute severe asthma and hypercapnia. Heliox was administered by face mask in blends between 60-70% helium (60:40 to 70:30) and led to reductions of mean P_{aCO_2} from 60 to 48 torr. These studies did not include control subjects, but the time-course response suggested benefit related to breathing heliox.

We[28] prospectively examined the effects of heliox breathing in 27 nonintubated patients with acute asthma. Sixteen patients were used as their own controls, with observations before, during, and after breathing 80:20 heliox. In addition, a control group of 11 patients breathing air had duplicate measurements to control for possible time-related changes in airflow obstruction following concurrent bronchodilator treatment. We found that pulsus paradoxus (PP) decreased by 38%, and expiratory peak flows (PF) increased by 35% in patients breathing heliox (Figs. 1 & 2). These differences were statistically significant and were not seen in patients breathing air. Because PP indirectly reflects inspiratory muscle work, our data suggest that heliox reduces the work of breathing in patients with acute severe asthma. The observed improvement in expiratory flows would allow expiration to a lower end-expired lung volume (to a more compliant portion of the pressure-volume curve) which would also reduce respiratory muscle elastic loads and help avoid adverse effects of hyperinflation.

We also studied the effects of heliox in children with acute bronchospasm.[29] PP fell by more than 50% with significant improvements in dyspnea for children breathing heliox. Although heart rate, respiratory rate, and other variables did not change appreciably during heliox, our data suggested that heliox also reduced work of breathing and breathlessness in spontaneously breathing children with asthma, undergoing treatment in the emergency room. In another study recently reported by Carter and colleagues,[30] children with asthma were randomized to receive either air or heliox breathing after admission to the unit. Subjects were enrolled for as long as 3 days after their admission date. A statistically greater peak expiratory flow rate was seen with heliox breathing, but forced expiratory volume in the first second, forced vital capacity, dyspnea score, and clinical asthma score were not different between the groups. In comparing these 2 investigations, it is notable that the former demonstrated a marked improvement in PP, and the latter a marked improvement in peak expiratory flow—both findings were also seen in our study.[28] The different outcome in dyspnea scores between the 2 pediatric studies may relate to the difference in patient populations—one studied acutely ill children in the emergency medicine department, and the other included patients who had received 12-96 hours of inpatient bronchodilator treatment. The finding of more apparent clinical benefit in patients seen in the emergency unit setting suggests that heliox breathing is of greater utility in the early treatment of acute asthma as opposed to heliox breathing after sustained bronchodilator therapy.

In a study examining the efficacy of heliox in intubated asthmatics, 7 patients with severe bronchospasm refractory to maximal conventional therapy received heliox.[31] Substitution of 60:40 heliox for oxygen enriched air resulted in a 15-50% reduction in peak inspiratory pressure and a 30-60% reduction in P_{aCO_2}. Because tidal volumes were not well measured and no controls were included in this study, whether heliox caused these improvements and the mechanisms by which they occurred is unclear.

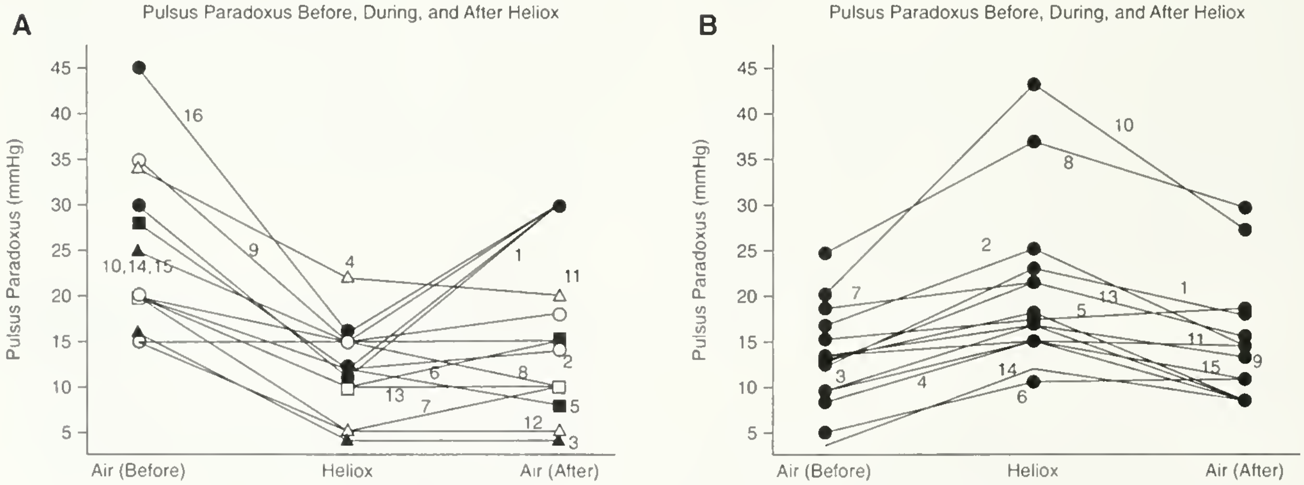

Fig. 1. The effect of heliox breathing on pulsus paradoxus (PP) and peak flow (PF) (PP > 15 mm Hg, PF < 250 L/min) in patients with severe acute asthma treated in the emergency room. Panel A. PP before, during, and after heliox breathing. PP decreased in 15 of 16 patients within 15 min of the institution of heliox and rose again in 7 of 16 patients 15 min after the resumption of air breathing. In the remaining 9 patients, PP decreased in 3 and remained the same in 6, 15 min after the resumption of air breathing. Panel B. PF before, during, and after heliox breathing. Peak flows increased in all patients after 15 min of heliox breathing and went back down in 13 of 15, 15 min after the resumption of air breathing. (Reproduced with permission from Reference 28).

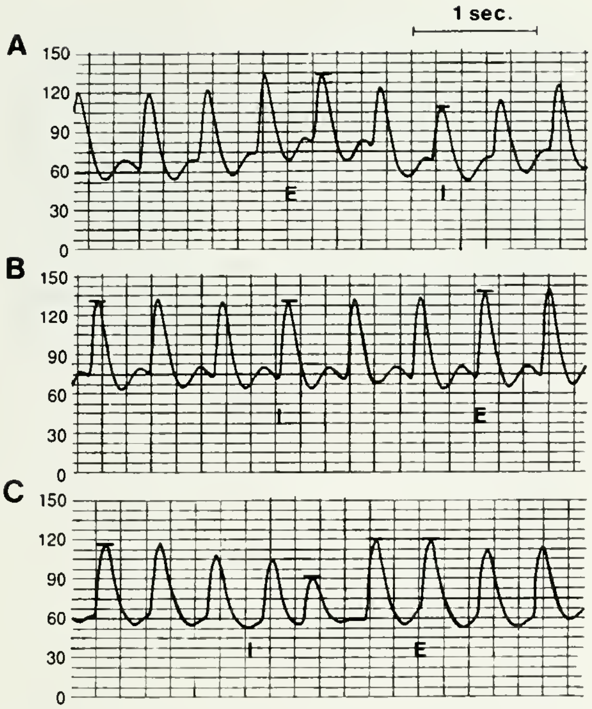

Fig. 2. Radial artery pressure tracings from a patient with severe acute asthma before (A), during (B), and after (C) the administration of 80:20 heliox. Pulsus paradoxus on air before heliox (45 mm Hg) decreased after 15 min of heliox breathing to 16 mm Hg on heliox and rose again to 23 mm Hg with resumption of air breathing. In the marked respiratory-phasic changes in the amplitude of the pressure tracing, the amplitude (pulse pressure) decreased by at least half with each inspiration during air breathing. Without heliox breathing this patient appeared in imminent respiratory failure, a clinical appearance that resolved with continued heliox therapy. The patient was returned to heliox breathing after the study period until a clinical response from bronchodilator treatments was obtained. (Reproduced with permission from Reference 28.)

Chronic Obstructive Pulmonary Disease (COPD)

The effectiveness of heliox for patients with acute exacerbations of COPD has not been well documented. Fifteen patients with stable COPD demonstrated a 15% improvement in functional residual capacity and small decrements of both P_{aCO_2} and CO_2 production after breathing an 80:20 blend of heliox.[32] In a study[33] published only as an abstract, 6 patients with acute or chronic hypercapnic respiratory failure due to COPD experienced reductions in mean P_{aCO_2} from 80 to 53 torr with 70:30 heliox breathing. Mean P_{aCO_2} rose again to 70 torr after resumption of air breathing.

Nebulization of Aerosolized Medications

Several researchers have examined the use of heliox to produce and deliver aerosolized medications.[34,35] Anderson et al[34] studied 10 patients with stable asthma, who inhaled radiolabeled particles suspended in heliox and in air. Heliox led to less deposition in the mouth and throat and more in the lungs compared to aerosols created with air. In 42 patients who were treated for acute severe asthma, patients randomized to receive β agonist aerosolized in heliox tended to experience a greater acute improvement in their peak expiratory flows than patients who received air-driven treatments.[36]

Fiberoptic Bronchoscopy (FOB)

Heliox has also been used to reduce respiratory resistance in patients undergoing fiberoptic bronchoscopy (FOB). Pingleton et al[37] demonstrated that a 70:30 blend of heliox reduced peak airway pressures with little change in static airway pressures (as compared to air) in intubated patients undergoing FOB. However, no data are provided to allow any conclusions regarding the superiority of heliox to air breathing during FOB. Because most FOBs are performed safely with air breathing, heliox may play a role in a subset of patients with small endotracheal tubes or with baseline elevations in resistive airway pressure.

Logistics—How To Administer Heliox

When greater than 30% oxygen concentrations are required to maintain arterial saturation greater than 90%, heliox may provide less benefit in reducing airways resistance. Complicating disease processes (eg, pneumonia and asthma) should be considered when patients with apparent airflow obstruction exhibit severe hypoxemia and require high oxygen concentrations. Heliox breathing may improve gas exchange,[38,39] presumably by improving ventilation-perfusion relationships or improving distal gas mixing and diffusion. To the extent this occurs, oxygen concentrations may be further reduced, permitting maximal concentrations of helium.

Nonintubated Patients

In spontaneously breathing patients not requiring positive pressure assistance, heliox is delivered by a nonrebreather face mask in order to reduce the amount of external air entrained on inspiration with resulting dilution of helium concentration (Fig. 3). A tank of dry 80:20 heliox is connected by plastic tubing to a tight-fitting face mask on the patient.

In our experience, flows of 5-10 L/min are enough to ensure that the reservoir bag of the rebreathing mask has enough gas for each tidal breath. We monitor all patients in an intensive or intermediate care unit with pulse oximetry; and, if supplemental oxygen is required to maintain the saturation more than 90%, we place a nasal cannula of oxygen beneath the mask and titrate supplemental oxygen to this end point. The rationale for this approach is to dilute the helium as little as can be safely done as defined by an O_2 saturation > 90%. We are careful to obtain an arterial blood gas within 20 minutes

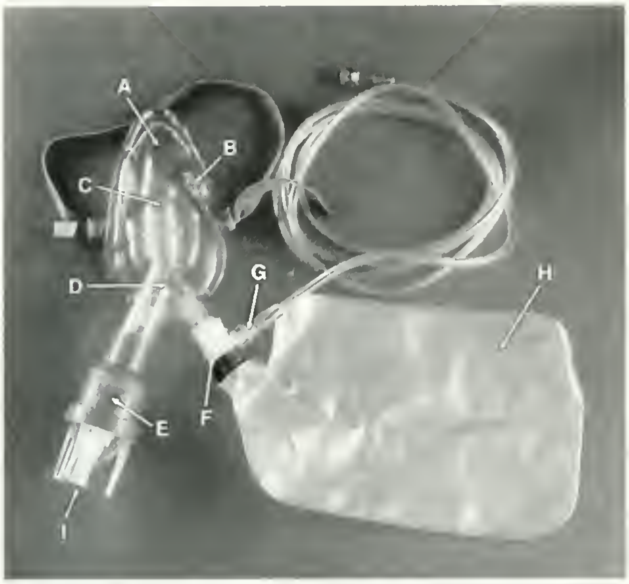

Fig. 3. A mask system for delivery of heliox and concurrent nebulization treatments in spontaneously breathing patients with severe airflow obstruction. A = Partial nonrebreather mask; B = Exhalation valve; C = 22mm ID adapter; D = Ventilator Y; E = Mini-Heart nebulizer® or Uni Nebulizer®; F = One-way valve; G = Connection for oxygen tubing to heliox tank; H = Reservoir bag; I = Port for nebulizing medication.

of the institution of heliox breathing to confirm the accuracy of the pulse oximeter.

Intubated Patients & Patients Receiving Positive Pressure Ventilation

The use of heliox through conventional mechanical ventilators may be challenging and should never be attempted for the first time in the crisis represented by life-threatening asthma. Before attempting heliox therapy in a patient, we recommend that physicians and respiratory therapists familiarize themselves with the processes that are confounded during heliox administration by applying their system to a test lung, adjusting gas flow, and making measurements of volume and flow.

A major problem resulting from heliox administration through all commonly available ventilators is error in flow measurement. Ventilators that use a hot-wire pneumotachometer (eg, Puritan-Bennett 7200) will have erroneous flow measurements because heliox has a higher specific heat than air and results in a greater cooling of the detector wire at any given flow. In addition, heliox causes the anti-asphyxia valve to open so that tidal volume is vented to the atmosphere. These problems taken together cause such a disparity between set and delivered tidal volume[40] that we do not use ventilators with this system for the delivery of heliox. Siemens Servo 900 and 300 series ventilators utilize a screen pneumotachometer that measures a pressure drop across the device related to the flow. This type of pneumotach is also affected by the use of heliox because the higher viscosity of heliox causes a lesser pressure drop and an under estimation of the flow. With the ventilator set in any volume-controlled mode, the ventilator 'increases' flows to meet the set tidal volume, causing the delivered tidal volume to exceed the set tidal volume. This can be undesirable in severe airflow obstruction and can result in increased hyperinflation with the potential for barotrauma and circulatory compromise.[10] Failure to recognize this phenomenon can result in a disastrous paradox—the clinician who initiates heliox therapy with the goal of reducing airway resistance and dynamic hyperinflation with its adverse consequences may not know that the ventilator 'upregulates' tidal volume, causing an increase in lung overinflation. While one study[41] has suggested that these errors in tidal volume measurement are small and can be corrected with a relatively simple calibration factor, we recommend that clinicians not rely on the measurements given by the ventilator. In our opinion, a better solution is to adjust tidal volume to other variables correlating to the degree of lung inflation (eg, plateau airway pressure and intrinsic positive end-expiratory pressure [$PEEP_i$]) and to measure tidal volume directly with a spirometer applied to the expiratory limb of the ventilator. In our experience, the measurement of the fraction of inspired oxygen by the usual in-line systems in modern ventilators is not confounded by heliox and is reliable.

We use the Siemens Servo 900 C or 300 E* for delivery of heliox during mechanical ventilation of severe asthma (Fig. 4). The blender for the machine should be changed to a low-flow blender, such as the Bird 3800 Microblender with two 50-psi outlets and a flowmeter to provide external access for a resuscitation bag. This change is recommended because the standard high-flow blenders contain a bleed-off valve that 'misinterprets' flow with heliox and results in a leak that requires frequent replacement of the heliox cylinders. A heliox CGA 280 gauge should be attached to the heliox H-cylinder and set for 40-50 psi. A Diameter Index Safety System connection is utilized to provide a bridge between gauge and blender (Fig. 4). A simple volume spirometer is attached to the expiratory limb to determine tidal volume by direct measurement. For this purpose, we use the volume spirometer from an MA-1 Puritan Bennett ventilator. If a Wright's spirometer is used, calibration for heliox would be necessary.

This system can be readily used to administer heliox and adjust ventilator variables. The majority of patients considered for heliox therapy combined with mechanical ventilation are heavily sedated and likely muscle relaxed, although paralysis should always be avoided if sedation alone is adequate because the incidence of post-paralytic myopathy is high in this group of patients.[10] The use of sedation

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*Suppliers of commercial products are listed in the Product Sources section following the text.

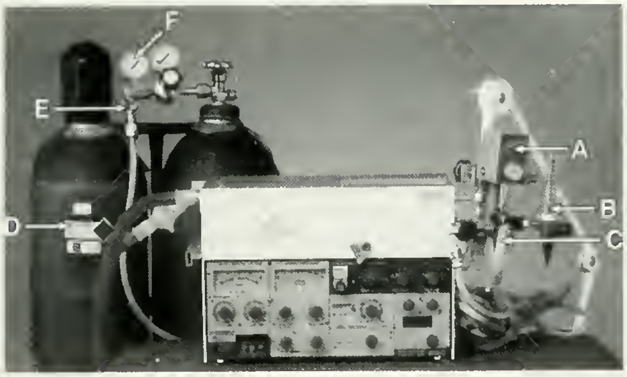

Fig. 4. Use of heliox with the Siemens 900 C ventilator. A = Bird low-flow blender (3800)®; B = 1-15 L/min flowmeter; C = 2-50 psi outlets with high pressure hose; D = Cylinder identification; E = Diameter-Index Safety System (DISS) connection for oxygen and air; F = Heliox regulator.

and paralysis facilitates controlled hypoventilation, reduces muscle work and, hence, CO_2 production, and assures patient-ventilator synchrony.

We prefer managing patients in the SIMV rather than the assist-control mode. This does not relate to the issue of patient-triggering because, as previously stated, these patients should have controlled ventilation. The use of SIMV is based on the independence of rate and minute volume changes that occur as heliox is adjusted and corrections are made for tidal volume alteration.

Ventilation with heliox should be started at the maximal concentration of helium that permits > 90% saturation of arterial hemoglobin. The benefits of heliox to lung mechanics require a fraction of inspired helium > 0.6. As heliox replaces the previous oxygen-nitrogen mix, tidal volume as measured by direct spirometry will rise above that set on the ventilator. The actual exhaled tidal volume will be about one third greater than the set tidal volume when a patient is inhaling 80:20 heliox, but direct measurement of the exhaled volume should be done to confirm this.

Once the patient has been ventilated for several minutes with heliox, a steady state regarding lung mechanics will be achieved. Tidal volume can be adjusted downward as measured by spirometry. Alternatively, one can simply adjust tidal volume to other end points of hyperinflation—specifically to maintain plateau airway pressures less than 30 cm H_2O and $PEEP_i$ less than 15 cm H_2O; in patients who have no contraindication to elevation of the P_{aCO_2}, permissive hypercapnia may be employed as part of this strategy.[10] Success of heliox therapy as compared to conventional gas ventilation would be proven by a lower P_{aCO_2}, a lower plateau airway pressure, and a lower $PEEP_i$, all compared at the same tidal volume and breathing rate. To prove this benefit, tidal volume measurement would have to be performed as previously described. One should be less ready to interpret a lower peak airway pressure as beneficial (although it will follow from improvement in the other variables) because the lower pressure is expected with the lower density gas and does not correlate well with the degree of hyperinflation.[10]

This same system may be used in the delivery of noninvasive positive pressure ventilation (NPPV) via a mask system (ventilator mode set to CPAP or Pressure Support). NPPV has been widely used in the management of patients with exacerbations of COPD and in recent studies improved survival.[41] The utility of NPPV in status asthmaticus is less clear,[42] and we would consider the combined therapy of heliox with NPPV to be experimental for these patients.

Aerosol Delivery

Adaptation of heliox cylinders to drive nebulizers for the delivery of inhaled bronchodilators is straightforward. We have used this approach with albuterol administration and a mini-Heart nebulizer connected by a ventilator-Y to a nonrebreather mask with reservoir (Fig. 3). The nebulizer is driven by the heliox H-cylinder with flows of 2-4 L/min.

Cost of Heliox Therapy

The cost of heliox per tank varies regionally (at present, $70/tank in Connecticut, $30/tank in Illinois). Approximately 3-6 tanks are required for treatment of the nonintubated patient for 24 hours. Thus, the cost of heliox therapy compares favorably with mechanical ventilatory support of the airflow obstructed patient; and, hence, if ventilatory failure can be avoided, heliox may be a preferred therapy on a cost as well as efficacy basis. Because the benefits of heliox therapy are less well described when coupled with mechanical ventilation or aerosol therapy, cost-benefit analysis is entirely speculative.

Clinical Recommendations

Available studies do not conclusively demonstrate the efficacy of heliox as primary or standard therapy for any disease entity. However, we believe that heliox can be a useful adjunct when it is used cautiously in selected patients.

Upper Airway Obstruction

The theoretical justification for the use of heliox in patients with upper airway obstruction is perhaps the most compelling. Yet, there are few prospective studies that substantiate the efficacy of heliox in this setting.[23] We use heliox in selected cases. Patients with severe obstruction and impending respiratory muscle failure should be intubated immediately to relieve the obstruction. Likewise, patients should be intubated if their airway obstruction is unlikely to be medically reversible. However, in patients with moderately severe obstructions that may be amenable to medical therapies (ie, selected patients with

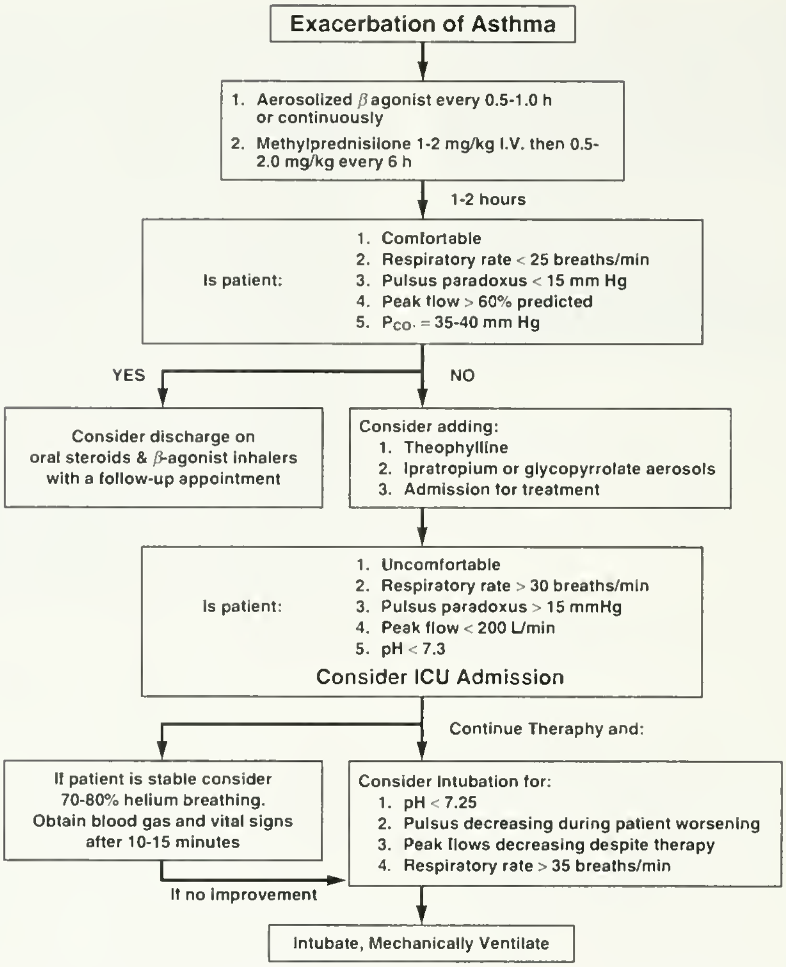
Exacerbation of Asthma
1. Aerosolized β agonist every 0.5-1.0 h or continuously
2. Methylprednisilone 1-2 mg/kg I.V. then 0.5-2.0 mg/kg every 6 h
1-2 hours
Is patient:
1. Comfortable
2. Respiratory rate < 25 breaths/min
3. Pulsus paradoxus < 15 mm Hg
4. Peak flow > 60% predicted
5. P_{CO}. = 35-40 mm Hg
YES
NO
Consider discharge on oral steroids & β-agonist inhalers with a follow-up appointment
Consider adding:
1. Theophylline
2. Ipratropium or glycopyrrolate aerosols
3. Admission for treatment
Is patient:
1. Uncomfortable
2. Respiratory rate > 30 breaths/min
3. Pulsus paradoxus > 15 mmHg
4. Peak flow < 200 L/min
5. pH < 7.3
Consider ICU Admission
Continue Theraphy and:
If patient is stable consider 70-80% helium breathing. Obtain blood gas and vital signs after 10-15 minutes
If no improvement
Consider Intubation for:
1. pH < 7.25
2. Pulsus decreasing during patient worsening
3. Peak flows decreasing despite therapy
4. Respiratory rate > 35 breaths/min
Intubate, Mechanically Ventilate

Fig. 5. The use of helium breathing in an algorithm for the treatment of exacerbations of asthma. Heliox is recommended for the most severely ill patients not responding to routine bronchodilator treatments but not yet requiring intubation and mechanical ventilation.

airway edema or infection), heliox may act as a bridge therapy to reduce resistance and tip the balance in favor of the respiratory muscles until therapies take hold. The most commonly encountered clinical scenario in which we use heliox for this indication is in post-extubation stridor.

COPD

We do not routinely use heliox in our patients with exacerbations of COPD. Because noninvasive face mask ventilation has been proven effective in many of the patients who might be candidates for heliox therapy, further studies are required to confirm the efficacy and the role of heliox in the management of patients with severe COPD.

Asthma

The majority of patients with severe exacerbations of asthma are successfully treated with routine therapy. Another small subset of patients requires immediate urgent intubation. A relatively small subset of patients with status asthmaticus that is not rapidly improving and who still have respiratory muscle reserve (patients who are not exhausted and nearing respiratory arrest) may benefit from breathing heliox until definitive therapies take hold (Fig. 5). We continue the heliox delivered by nonrebreather face mask until the patient has clinically improved (usually within 24 hours) allowing a trial of air breathing. Because the scientific data do not unequivocally demonstrate the effectiveness of this modality, when we initiate heliox therapy in these tenuous asthmatics, we do not leave the bedside until the patient has become more comfortable and serial arterial blood gases confirm that P_{aCO_2}, if initially elevated, is decreasing. Because these patients are close to requiring intubation, we have a senior clinician skilled in airway management assigned to the patient to be immediately available.

Even though heliox may be effective at reducing airway pressures and improving gas exchange in intubated asthmatics, its use remains experimental. First, the majority of intubated asthmatics improve with conventional ventilator therapies. However, there is a small subset of patients with extreme hyperinflation as indicated by measurement of plateau airway pressure and $PEEP_I$.[10] Because studies have suggested that asthma mortality can be nearly eliminated by ventilating these particularly severe asthmatics at low (< 30 cm H_2O static) airway pressures, with or without permissive hypercapnia,[44,45] this strategy should be attempted before using heliox in mechanically ventilated patients. There are few patients who cannot be stabilized using the permissive hypercapnia strategy. Thus, in our opinion, heliox has a very limited role in intubated asthmatics.

Aerosol Therapies

The vast majority of patients with exacerbations of asthma improve with β agonist aerosolized in air. Even if heliox is superior to air as a vehicle for aerosol therapies, it is unlikely that the difference will be enough to justify routine use of heliox for this indication. However, it is possible that heliox-driven nebulized therapies may be helpful in very severe asthmatics and/or in intubated asthmatics whose asthma is not responding to air driven aerosols.

In Conclusion

The early reports by Barach suggest that heliox may be an effective adjunct for patients with obstructive pulmonary diseases. More than 60 years have passed, and still there are inadequate data to definitively determine the efficacy of heliox and its appropriate place in the armamentarium against respiratory diseases. More prospective clinical studies are required to further define the niche for this therapy first proposed in 1934.

PRODUCT SOURCES

Ventilators:
Siemens Servo 900 C or 300 E, Siemens-Elema AB, Sweden

Blenders:
Bird 3800 Microblender, Bird Products, Palm Springs CA

Gauges:
CGA 280 gauge, Best Technology Corp, Lombard IL

Spirometers:
Wright's Spirometer, British Oxygen Co, Ferraris Medical Inc, Holland NY

Cylinders:
Heliox H-Cylinder, Nellcor Puritan Bennett Gas Division, Lagrange IL

Nebulizers:
Mini-Heart Nebulizer,Vortran Medical Technology Inc, Sacramento CA

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Books, Films, Tapes, & Software

AIDS Sourcebook Health Reference Series: Volume 4, edited by K Bellenir and PD Dresser. 831 pages. Detroit: Omnigraphics Inc; 1995. $80.

The text is presented in 7 parts and includes 76 chapters that explore every topic from the historical development of acquired immunodeficiency syndrome (AIDS) to resources for the religious community. The handbook is designed for human immunodeficiency virus (HIV)-positive and AIDS patients and their families—the respiratory care practioner's (RCP) interest in this text may be as resource material or as an informative text for patients.

Parts I and II deal with historical and statistical information about AIDS and HIV infection and reports from the National Commission on AIDS. Part III, Living with HIV/AIDS—Medical Information for the HIV/AIDS Patient, is the most comprehensive section in the text. It is written (as is the entire volume) in layperson's terms and includes virtually every medical question—from the immune system to how to go about joining a clinical trial—that a patient might have. The last chapter in this section lists additional resources for medical information.

Coping with Social, Legal, Psychological, and Emotional Issues is covered in Part IV. This section covers counseling and testing, how HIV affects employment and health insurance, the Americans with Disabilities Act, a guide to proper nutrition, HIV/AIDS and sports, caring for someone with AIDS, and talking to children and adolescents about HIV/AIDS. A positive feature of this section is that information is provided through several question-and-answer sections, presenting pros and cons associated with each question. For example, the text includes both reasons for and against seeking counseling and testing. In this way, the patient is presented with the information and then left to make decisions based on individual beliefs and circumstances—there is no 'correct' course of action. Parts III and IV probably provide the answers to the most frequently asked questions by HIV/AIDS patients.

Part V covers AIDS prevention, including Center for Disease Control guidelines. Part VI examines AIDS research—this section could easily be intimidating to readers but is written in the same easy-to-understand language used throughout the text. While it certainly is not an exhaustive review of the medical literature, Part VI discusses AIDS drugs, vaccines, and transmission of the virus through health care workers, dentists, and mother to infant.

Part VII concludes the text, with a thorough list of resources, including AIDS Hotlines (state by state), guides to find more information, education, and training centers, prevention programs, Internet resources, and resources for the religious community.

Overall, the AIDS Sourcebook is a comprehensive guide for patients and their families living with HIV/AIDS. It is well written, easy to understand, and thorough. Users of the sourcebook can easily find the answers to their questions by either using the index or perusing the 7 parts and subsequent chapters. I would not hesitate to refer patients to this text or to use it myself as a resource for classroom instruction.

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Fitness and Exercise Sourcebook edited by DR Harris. 625 pages. Detroit: Omnigraphics Inc; 1996. $80.

This book is an encyclopedia of sorts that provides information on a broad range of topics related to physical fitness and exercise. There are 5 main sections, each featuring a compilation of publications previously produced by various health and fitness agencies and consumer magazines.

Section 1 deals with the fundamentals of exercise: definitions and benefits of physical fitness, methods of fitness assessment, general advice on planning and developing a fitness routine, tips for long-term adherence, and the impact of exercise on weight control. The 4-step plan in Chapter 3 outlines the thought process involved in beginning an exercise program, accounts for the barriers, individualizes the plan, and strategizes for "commitment." The plan is an excellent guide for any individual wishing to begin a program. This plan may be useful to both the general public or the clinician involved in counseling individuals on exercise and may merit the price of the book on its own. Also quite useful is the general test battery presented for assessment of physical fitness. This battery of tests is practical, simple, and can be performed by anyone. The descriptions of these tests, however, are wordy and could have been illustrated to guide the reader in proper administration.

Section 2 presents information on the role of exercise in health across the age spectrum and the impact of nutrition on sports performance. The information in this section is vague. The exercises presented are described generally in the text but, again, could have been supplemented with illustrations. If done improperly, some of the exercises, such as the quarter squats and leg lunges, for "mid-life and older persons" may be contraindicated in a large segment of this population. Additionally, there are no specific workout routines presented for each age group, and the information on warm-up and cool down is redundant to the previous section.

Exercise recommendations specific to individuals with chronic medical conditions such as arthritis, diabetes, and heart disease are included in Section 3. Advice is also presented on exercise and pregnancy, mental health, asthma, and general tips for individuals with hip replacement. Most chapters in this section are lacking some basic components. The chapter on arthritis contains only minimal examples of specific range-of-movement exercises. The diabetes chapter is vague on issues such as recognition and treatment of hypoglycemia, blood sugar responses to exercise, and the necessity for daily exercise in promoting optimal blood glucose control.

Section 4 contains information about specific fitness activities. The general tips presented in each chapter such as cycling technique, shoe technology, choosing the right health club, and exercise equipment selection provide individuals with practical insights necessary to enjoying each activity to its full potential. Lacking in this section are detailed sample exercise routines for many of the activities listed. The omission of weight training routines is perhaps the most glaring example of this weakness.

An excellent literature review of the most up-to-date research on the benefits of physical activity covering a wide range of health-fitness-related topics is provided in Section 5. This section is somewhat scientific for the layperson but serves as an excellent resource for the fitness professional in need of quick access to scientific data.

From a practical point of view, the book covers a wide range of topics. This scope leaves little room for specific detail, which may force the reader to consult alternate sources devoted to a specific fitness or exercise activity. Due to the large overlap of subject matter there is considerable redundancy in many chapters, and the lack of illustrations creates potential for confusion on the part of the reader. General texts on specific exercise-related topics may better serve the individual interested in learning more on exercise and fitness.

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Respiratory Disease in Children: Diagnosis and Management, GM Loughlin and H Eigen, Editors. Illustrated, 867 pages. Baltimore: Williams & Wilkins; 1994. $125.

According to the foreword, this book targets "the practitioner facing the problems of children with lung problems that threaten lives or that at least won't go away." In a few pages, the first section of the book covers maturation of the respiratory system. Although the authors do a good job, much of the detail is left out—probably due to page limitations. I found this section to be the easiest to read and understand.

The second section discusses diagnostic techniques. The first chapter covering physical assessment is interesting and informative without going into exhaustive detail. In just 9 pages it covers all the important aspects of the physical exam, including reminding the practitioner to warm the stethoscope before auscultating the chest. In the chapter, "Imaging the Pediatric Chest," Figure 9.42 shows a normal and inflamed epiglottis; however, the descriptions and the pictures are reversed—the normal epiglottis is View B not A; and the inflamed epiglottis, View A not B. I found the rest of the section also easy to read and informative. There are a number of tables in the bronchoscopy chapter that may be helpful to those who are developing a bronchoscopy program.

The third section of the book is about approaching the patient with pulmonary disease. The chapters are well written and contain some good information on how to differentiate pulmonary diseases.

Section 4 describes common pulmonary diseases. Each chapter covers a specific disease or class of diseases and describes clinical presentation and management. The chapters are informative and contain many tables to help with differential diagnosis.

Section 5 covers respiratory aspects of nonpulmonary disease. The authors do a good job of describing the causes and management of such disorders.

Section 6 covers the principles of therapy for pulmonary diseases. I found the oxygen therapy chapter disturbing. The authors' description of the venturi mask (ie, air-entrainment mask) states, "the larger the air intake port the lower the final F_{IO_2}." This statement is contrary to how the air-entrainment mask functions. The air intake port does not change size; it is the size of the orifice for O_2 that changes. The authors also state that "face masks deliver higher oxygen concentrations, approximating 100% under ideal circumstances." Though this is true for the nonrebreather mask, it is not true for a simple mask or an aerosol mask. This chapter includes brief information about oxygen delivery for the home. The authors' recommended form of oxygen delivery to infants with bronchopulmonary dysplasia is an "inverted tent." This system seems very dangerous to me because the plastic that lines the sides, bottom, and top half of the crib could be a cause of asphyxiation in the child who happens to get its face between the mattress and the side of the crib. Though they have their drawbacks, I believe, nasal cannulas are safer, less expensive, and better tolerated than the "inverted tent" system. This chapter needs to be reworked to improve the accuracy of the oxygen therapy information.

I would not recommend this book for respiratory therapy, nursing, or medical students. The information about lung maturation and disease processes is good and may be valuable to its target audience of practicing respiratory therapists, nurses, and physicians. However, the chapter on oxygen delivery may be confusing to those who do not have a firm understanding of oxygen delivery devices and how to use them.

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Bilateral Upper Lobe Cavities: The Lesions Are Obvious but What about the Cause?

Samer Alkhuja MD, Anthony J Mastellone MD, and Albert Miller MD, FACP, FCCP

Case Summary

A 70-year-old woman was admitted to the hospital for evaluation of a syncopal episode. She denied cough and other respiratory symptoms and did not smoke. Four months earlier she had undergone sigmoidoscopy for evaluation of hematochezia. At that time she had been found to have moderately differentiated adenocarcinoma of the rectum with hepatic metastases. Surgeons established a colostomy, and the patient subsequently received chemo- and radiotherapies. Results of the physical examination performed during the current admission were unremarkable. The chest radiograph is shown in Figure 1.

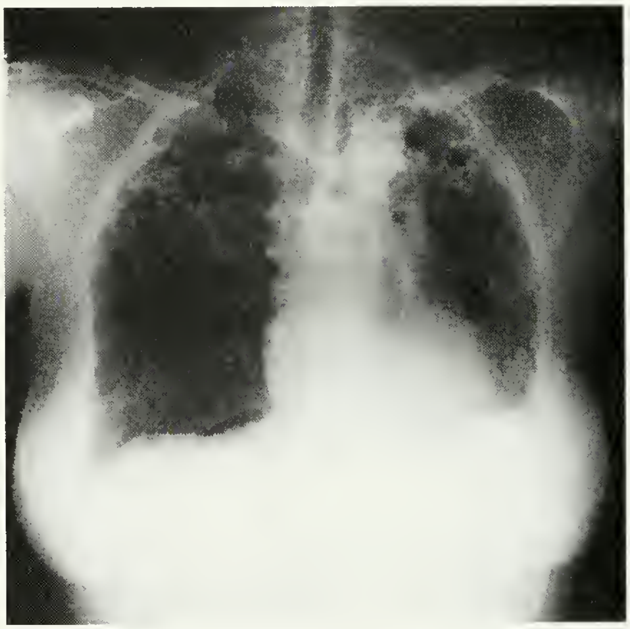

Fig.1. Posteroanterior radiograph of 70-year-old woman admitted to the hospital for evaluation of a syncopal episode.

How would you answer these questions?

What abnormalities are apparent on the radiograph?

What is the most likely etiology of the cavities?

What steps should be taken immediately?

Answers & Discussion on next page

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Answers

Abnormalities. Thin-walled cavities are present in both upper lobes and a round density can be seen in the superior mediastinum.

Etiology. Given the patient's age and immunosuppressed state, the cavities are likely to be the consequence of infection with *Mycobacterium tuberculosis* (ie, tuberculosis, or TB).

Immediate Procedures. The patient should be placed in respiratory isolation, and anti-tuberculosis drugs should be begun. It is important to establish the presence or absence of tuberculosis.

The patient was placed in isolation and received four antituberculosis medications while the diagnosis was being made. Induced sputum stained by the Kinyoun and fluorochrome techniques was negative for acid fast bacilli (AFB). A bronchoscopy revealed no endobronchial lesions. Smears from the bronchial washings, brushings, and transbronchial biopsies were also negative for AFB. Histopathologic examination of the bronchoscopic biopsies and cytology results of tissues from both upper lobes revealed clusters of malignant cells consistent with the diagnosis of metastatic adenocarcinoma similar to the primary rectal lesions. A needle biopsy was refused by the patient. She remained hospitalized and expired after three weeks because of a cardiac arrest.

Discussion

The coexistence of pulmonary TB with primary or secondary lung cancer has been reported;[1] and, because our patient was receiving chemotherapy and had cavities on chest radiograph, the diagnosis of pulmonary tuberculosis was considered, but all cultures were negative. The absence of respiratory symptoms and the presence of bilateral upper lobe cavities simulating TB on chest radiograph make this case unique.

The lung is a common site for spread of malignancies, with pulmonary metastases occurring in 30-40% of all patients with cancer. In primary colorectal cancer, the autopsy incidence is approximately 20-40%, with the lung as the only site of metastases in 9%.[2] However, lung recurrences of rectal carcinoma after potentially curative surgery have been reported in 117 of 1013 patients (11.5%).[3] In that series, half of the lung recurrences were clinically obvious within 32 months.

Metastases to the pulmonary parenchyma are most often asymptomatic. However, symptoms may include cough, hemoptysis, dyspnea, tightness or fullness in the chest, hoarseness, and pleuritic pain. Physical examination may reveal signs of pleural effusion, pericardial effusion, partial or total airway occlusion, or superior vena caval obstruction. Laryngoscopy may reveal cord paralysis.[2] Radiographic manifestations include pleural effusion, parenchymal masses, obstructive pneumonia or lobar segmental collapse, hilar and mediastinal adenopathy, linear markings, and, rarely, pneumonia.[2] Computed tomography (CT) of the thorax may play a role in the initial diagnosis and planning if radiation therapy or surgical resection are to be employed. Magnetic resonance imaging (MRI) offers no particular advantages over CT imaging, with the possible exception of better defining mediastinal or adrenal involvement.

Cavitation of pulmonary metastases is uncommon.[4] In what may be the first series reported[5] cavitation was observed in 16 of 398 (4%) consecutive patients with pulmonary metastases compared with 16 of 176 patients (9%) with primary lung tumors. The causes of cavitary lung lesions include infections, vasculitis, and neoplastic processes. Infectious cavities may be due to a mycobacterial infection, such as a necrotizing tuberculous pneumonia, and are seen after the caseous material has been liquefied and expectorated.[6] While cavitation is rarely seen in primary tuberculosis, cavities occur in about 35% of cases of reinfection tuberculosis.[6] Bacterial infections may appear as cavitary lesions, with cavitation seen 25-30% of staphylococcal pneumonia and as high as 75% of Gram-negative pneumonias. Septic embolizations, fungal and parasitic infections, and any noninfectious granuloma may cavitate.[6] Pulmonary infarcts only rarely cavitate and such cavitations are usually due to a superimposed infection.[6] Cavitation of pulmonary neoplasms, mainly squamous cell carcinoma, may result from ischemic necrosis secondary to neoplastic obstruction or thrombosis of an artery supplying the tumor resulting in central infarction; chemotherapy for pulmonary neoplasms may itself cause cavitation.[6] Other lesions that may mimic pulmonary cavitation are loculated pyopneumothorax, diaphragmatic hernia, sequestration, and collection of an air pocket in the inferior pulmonary ligament due to alveolar rupture secondary to chest trauma.[6]

In order to make a tissue diagnosis of a metastatic pulmonary lesion, a variety of procedures other than thoracotomy/thoracoscopy may be employed: sputum cytology (most useful for a cavitary or endobronchial lesion and for lymphangitic metastases); bronchoscopy with lavage, brushings or transbronchial biopsy,[7] and transthoracic needle aspiration. Treatment of pulmonary metastases should be individualized. Medical treatment may consist of chemotherapy, radiation, hormonal, or immunologic therapies. For most patients, palliative therapy is appropriate; opiates and oxygen therapy may relieve end-stage dyspnea. Pulmonary metastectomy may be indicated if adequate control of the primary site has been or can be obtained, the patient can tolerate the planned procedure, no evidence exists for metastatic disease at other sites, and lung reserve is adequate to withstand surgery.[8] Social, emotional, and physical rehabilitation have important roles.

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Graphics Corner

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Erratic Ventilator Triggering during Neuromuscular Blockade

Robert S Campbell RRT, Richard D Branson BA RRT,
Jay A Johannigman MD, Kenneth Davis Jr MD

Case Summary

A 25-year-old white woman was seen in the emergency department following a high-speed, frontal impact motor vehicle collision, in which she was the unrestrained driver. At the scene she was noted to be hypotensive but responsive with a Glasgow Coma Score of 9. In the field, endotracheal intubation was performed due to labored breathing and diminished breath sounds bilaterally. On arrival in the emergency department an anterior-posterior chest x-ray showed bilateral pneumothoraces. Bilateral chest tubes were placed, and air escape was noted on insertion of each. She remained hypotensive with a systolic blood pressure (BP) < 80 mm Hg, despite multiple fluid boluses and administration of 3 units of blood. Diagnostic peritoneal lavage was grossly positive, and the patient was taken immediately to the operating room for exploratory laparotomy.

A Grade-IV liver laceration was repaired, and the patient was admitted to the surgical intensive care unit postoperatively. Fluid resuscitation consisted of 13 units of packed red blood cells, 15 units of fresh frozen plasma, 1-ten pack of platelets, 2-ten packs of cryoprecipitate, and 10 L of crystalloid. Estimated blood loss intraoperatively was 4.0 L. The patient was 178 cm tall and weighed 123 kg—ideal body weight was estimated at 88 kg. Initial ventilator settings included pressure controlled-intermittent mandatory ventilation (PC-IMV) at a rate of 12 breaths/min and inspiratory pressure of 37 cm H_2O, which resulted in an exhaled tidal volume (V_T) of 0.95 L. Positive end-expiratory pressure (PEEP) was set at 8 cm H_2O, inspiratory time was 1.7 seconds, and F_{IO_2} was 1.0. Arterial blood gas results revealed a pH of 7.31, P_{aCO_2} of 45 torr, P_{aO_2} of 68 torr, base excess of −3.9, HCO_3^- of 22 mEq/L, and S_{aO_2} of 0.92.

A pulmonary artery catheter was placed to guide fluid resuscitation and monitor hemodynamic status. Initial hemodynamic profile showed a cardiac index of 2.9 L/min/m², pulmonary artery occlusion pressure 12 mm Hg, central venous pressure 10 mm Hg, mean pulmonary artery pressure 29 mm Hg, arterial BP 110/58 mm Hg, systemic vascular resistance of 990 dynes-cm², pulmonary vascular resistance of 79 dynes-cm², oxygen delivery of 1312 mL/min, and intrapulmonary shunt ($\dot{Q}_{sp}/\dot{Q}_{tot}$) of 0.35 (ie, 35%). Pharmacologic support included renal-dose dopamine (2.5 mcg/kg/min) and fentanyl at 100 mcg/min. Continuous fluid administration with both colloid and crystalloid products was required to maintain adequate systemic BP.

Over the next 12-hour period, 12 L of fluid were given to maintain systolic BP > 90 mm Hg, PEEP was incrementally increased to 26 cm H_2O due to hypoxemia ($\dot{Q}_{sp}/\dot{Q}_{tot}$ 0.56 and P_{aO_2} < 60 torr). Inspiratory time was increased to 1.9 seconds, and inspiratory pressure was increased to 44 cm H_2O to achieve an exhaled V_T of 0.7 L. The mandatory breath rate was increased to 10 breaths/min in order to maintain adequate minute ventilation (pH > 7.25). Epinephrine (3.3 mcg/kg/min), norepinepherine (2.1 mcg/min), dopamine (7.5 mcg/kg/min), and approximately 1500 mL/h of lactated Ringer's were necessary to maintain adequate systemic BP. Intra-abdominal pressure was measured (25 mm Hg), and both chest tubes were noted to be leaking air.

The nursing staff noted that the patient was triggering the ventilator. This observation was based on illumination of the Spontaneous and Assist light-emitting diode displays (LEDs) on the 7200ae ventilator (Nellcor Puritan Bennett, Carlsbad CA), the measured respiratory rate display reading of 12 breaths/min (set rate was 10 breaths/min), and the irregular breathing pattern seen on the pressure and flow waveform display. The decision to provide neuromuscular blockade was made so that expiratory time could be controlled in order to avoid intrinsic PEEP. A bolus of 10 mg vecuronium bromide was given and an infusion started at 3 mg/h. Assessment of

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the level of neuromuscular blockade was attempted using a peripheral nerve stimulator.[1] Train-of-four monitoring via the stimulator revealed zero of 4 twitches temporally and radially. Train-of-four monitoring was not considered to be reliable in this patient due to the presence of severe tissue edema.[2] The nursing staff continued to note the presence of patient-triggered breaths (pressure trigger set to −2.0 cm H_2O) and administered a second 10-mg bolus of vecuronium bromide and increased the infusion to 5 mg/h.

Patient-triggering continued after the second bolus, and the suggestion was made to give a third bolus. Prior to giving the third bolus of vecuronium bromide, the respiratory and critical care staff were asked to further evaluate the patient. The 7200ae respiratory rate display and LEDs continued to suggest patient inspiratory effort. All alarms were set appropriately, and the ventilator was not alarming at this time. The airway pressure and flow graphics were inspected carefully and are shown in Figure 1.

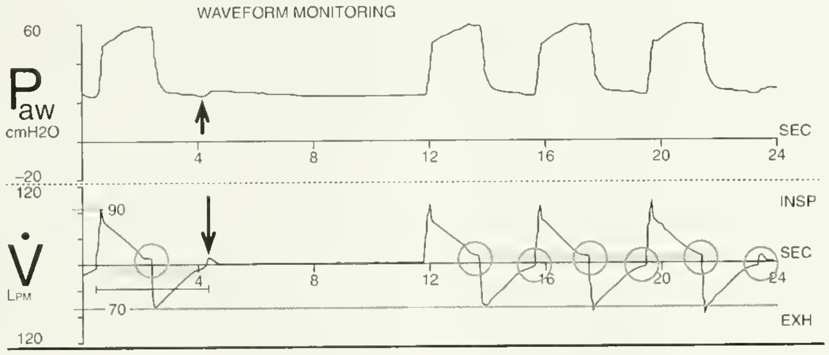

Fig. 1. Pressure and flow waveforms taken from the 7200ae ventilator graphics package. Ventilator settings include pressure controlled-intermittent mandatory ventilation (PC-IMV) mode, inspiratory pressure 36 cm H_2O, positive end-expiratory pressure (PEEP) of 26 cm H_2O, inspiratory time 1.9 s, rate 10 breaths/min, FIO2 0.7, sensitivity −2.0 cm H_2O. Monitored variables: exhaled tidal volume (V_T) 0.95 L, minute ventilation 11.6 L, respiratory rate 12 breaths/min, mean airway pressure 41 cm H_2O, and peak inspiratory pressure 62 cm H_2O.

How would you answer these questions?

Explain the breathing pattern depicted in this waveform.

What information can be determined by the inspiratory and expiratory flow waveforms?

What is the cause of the erratic breathing pattern?

Answers on next page

Answers

Breathing Pattern. Four mandatory breaths are delivered, and approximately 12 seconds elapse prior to the onset of the next mandatory breath. Three mandatory breaths are then delivered in rapid succession (< 8 seconds), with approximately a 2-second expiratory time for each breath.

Upon closer inspection, it can be seen that the ventilator actually senses 'patient effort' following the first mandatory breath and provides a spontaneous breath. This is confirmed by the illumination of the Spontaneous LED on the ventilator, but this is not actually a patient effort. It is a decrease in airway pressure resulting from the air leak through the chest tubes. The ventilator senses this drop in airway pressure below the set pressure sensitivity (−2.0 cm H_2O) as the patient trying to trigger a breath. The subsequent pause is present because the cycle criteria for the spontaneous breath is not being met. This was confirmed by the continuous illumination of the Spontaneous LED on the ventilator during the pause. Nonpressure-supported spontaneous breaths are normally cycled off on the 7200ae when the airway pressure exceeds the set PEEP-CPAP (continuous positive airway pressure) level by 1.0 cm H_2O.[3] Flow output of the ventilator during pressure-triggered, nonpressure-supported spontaneous breaths is adjusted to maintain airway pressure at PEEP-CPAP minus the sensitivity setting (in this case 24 cm H_2O). Because of the chest-tube air leak, airway pressure cannot exceed the PEEP-CPAP level, and the breath does not terminate until 2 breath cycles have elapsed.* A breath cycle or window is determined by dividing 60 seconds by the mandatory breath rate. In this case the window equals 6 seconds (60/10). The pause caused by the sensed spontaneous breath prohibits the delivery of a mandatory breath during the second breath window and explains the delivery of a mandatory breath after 12 seconds on the graph (beginning of the third window). This breath counts, however, as the mandatory breath for the second window. Following exhalation of this breath (approximately 2 s), inspiration is again triggered as a result of the chest-tube leak. A mandatory breath is delivered because the ventilator has not yet delivered a mandatory breath for the third window. Following exhalation of this breath (again, 2 s), a mandatory breath is delivered because it is initiated inside the fourth window (after 18 s from the onset of the first mandatory breath). The cycle of 3 mandatory followed by 1 'spontaneous' breath continued as a result of the 7200ae's 'trying' to maintain a mandatory breath rate of 10 breaths/min during synchronized intermittent mandatory ventilation.

Inspiratory-Expiratory Flow. First, inspiratory flow is decelerating as would be expected during pressure control. The peak inspiratory flow is approximately 90 L/min and does not reach zero prior to the end of inspiration on any of the mandatory breaths. A flow plateau of approximately 8-10 L/min is present at the end of inspiration and represents the flow necessary to maintain the set inspiratory pressure in face of the leak through the chest tubes. The peak expiratory flow (PEFR) varies among each of the mandatory breaths depicted on this graph. The PEFR increases slightly with each of the 3 consecutive mandatory breaths (62 L/min on the first breath, 70 L/min on the second, and 80 L/min on the third). This increase in PEFR results from the sequential increase in intrathoracic volume due to gas-trapping with each mandatory breath. Expiratory flow does not reach zero prior to the onset of inspiration which suggests the presence of intrinsic PEEP and gas-trapping.

Erratic Breathing Pattern. The erratic breathing pattern is caused by the combination of autotriggering, the inherent intermittent mandatory ventilation breath delivery algorithm of the 7200ae, and the breath termination criteria for spontaneous breaths not being met. Following the apparent 8-second spontaneous breath, the ventilator must give mandatory breaths at a higher rate in order to deliver 10 mandatory breaths in a minute. After 3 mandatory breaths are delivered within an 8-second period, the ventilator delivers a spontaneous breath that is autotriggered, and the cycle repeats.

To asses the presence of patient inspiratory effort, the pressure sensitivity was decreased to −10.0 cm H_2O. Figure 2 reveals the pressure and flow waveforms with −10.0 cm H_2O sensitivity.

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*J Henk, Manager, Clinical Application, Nellcor Puritan Bennett, Carlsbad CA, 1997: personal communication.

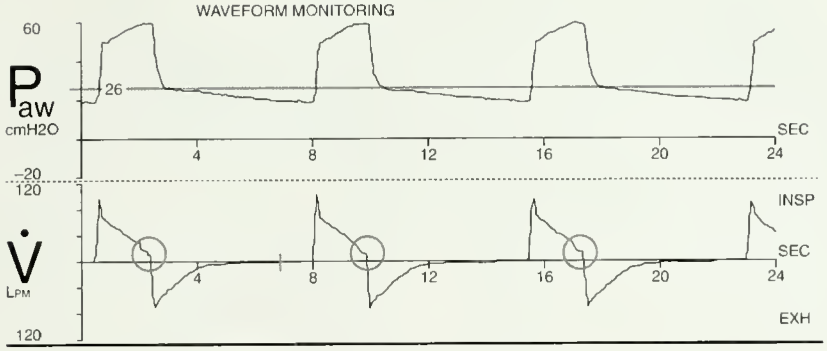

Fig. 2. Pressure and flow waveforms taken from the 7200ae ventilator graphics package. Ventilator settings are the same as in Figure 1, with the exception of pressure sensitivity set to −10 cm H_2O. Monitored variables: exhaled tidal volume (V_T) 1.09 L, minute ventilation 10.6 L/min, respiratory rate 10 breaths/min, mean airway pressure 31 cm H_2O, and peak inspiratory pressure 61 cm H_2O.

How would you answer these questions?

What is different about the expiratory portion of the airway pressure waveform?

Have the inspiratory or expiratory flow waveforms changed from Figure 1?

Answers on next page

Answers

Airway Pressure Waveform. Airway pressure is not stable during the expiratory phase due to the leak through the chest tubes. Airway pressure drops between 8 and 10 cm H_2O during the 6-second expiratory time. The reduction in airway pressure was barely visible in Figure 1 because the ventilator was actually in the inspiratory phase of the spontaneous breath and supplied flow necessary to 'feed the chest-tube leak' and maintain airway pressure at PEEP-CPAP minus sensitivity. In this figure, the decline in airway pressure during the expiratory time is obvious, because sensitivity has been reduced to -10.0 cm H_2O, thus prohibiting triggering or autotriggering of a spontaneous breath.

Inspiratory-Expiratory Waveform Changes. The inspiratory flow waveform appears similar with evidence of continued flow plateau at the end of inspiration. The presence of flow at this point represents the amount of flow necessary to compensate for the air leaking through the chest tubes and maintain the set inspiratory pressure.

Expiratory flow returns to zero in this figure for approximately 1 second prior to the next inspiration. The PEFR appears similar on each mandatory breath, and there is no suggestion of gas-trapping (intrinsic PEEP). The breathing pattern is now regular, and each breath is time-triggered according to the rate setting on the ventilator.

At this point, flow-triggering was initiated with a base flow of 5 L/min and flow sensitivity of 2 L/min in an attempt to stabilize expiratory pressure in the airway. Figure 3 reveals the pressure and flow waveform with these flow-triggering settings.

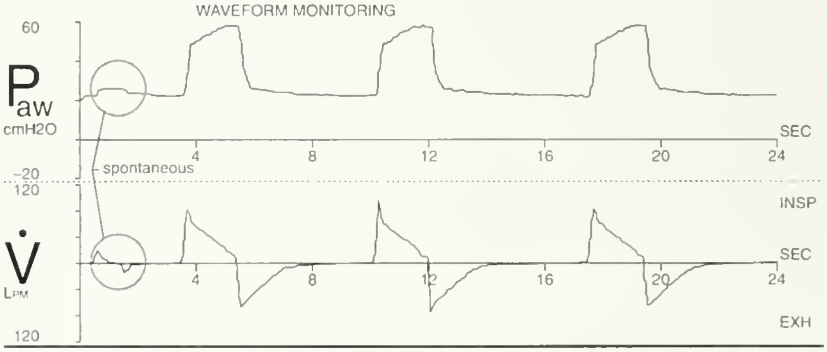

Fig. 3. Pressure and flow waveforms taken from the 7200ae ventilator graphics package. Ventilator settings are the same as in Figures 1 and 2, with the exception of flow-triggering set to base flow of 5 L/min and flow sensitivity of 2 L/min. Monitored variables: exhaled tidal volume (V_T) 0.98 L, minute ventilation 10.7 L/min, respiratory rate 11 breaths/min, mean airway pressure 29.7 cm H_2O, and peak inspiratory pressure 61 cm H_2O.

How would you answer these questions?

Explain the breathing pattern present in this waveform.

What is different about the airway pressure waveform compared to Figure 2?

Answers on Page 1055

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Answers

Breathing Pattern. The breathing pattern demonstrates a spontaneous breath followed by 3 mandatory breaths. The spontaneous breath can be identified by the small positive deflection present on the flow signal and the slight rise in the pressure waveform. The spontaneous breath in this case does cycle off normally. The cycle criterion for spontaneous breaths during flow-triggered breathing is expiratory flow exceeding inspiratory flow by 2 L/min.[3] During inspiration of flow-triggered, nonpressure-supported breaths, flow output is adjusted to maintain airway pressure at PEEP-CPAP plus 0.5 cm H_2O (in this case 26.5). Targeting a pressure above the PEEP-CPAP setting allows flow-triggered spontaneous breaths to be cycled off normally.

Airway Pressure Waveform. With the addition of a continuous flow of 5 L/min, the decrement in PEEP is reduced, but not eliminated. Through the course of the expiratory time, pressure falls approximately 4 cm H_2O or about half of that seen in Figure 2. This suggests that the base flow setting of 5 L/min is insufficient to maintain the PEEP-CPAP level considering the chest-tube leak. In addition, the combined chest-tube leak must be greater than 2 L/min as evidenced by the autotriggering present at this time.

In an effort to maintain the set PEEP-CPAP level and prevent autotriggering, the base flow was increased to 8 L/min, while flow sensitivity was increased to 4 L/min. Figure 4 reveals the airway pressure and flow waveforms present at these current settings.

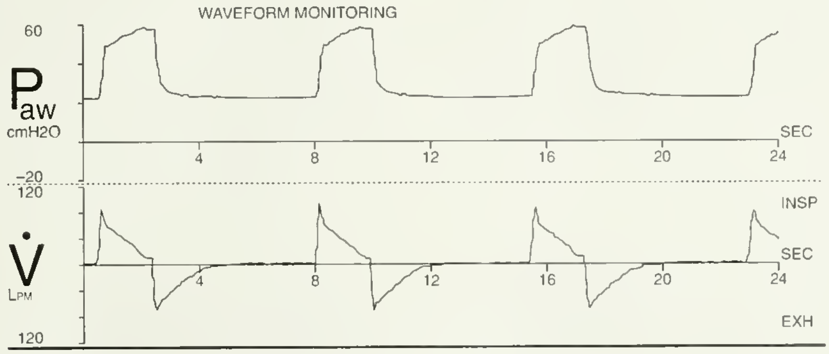

Fig. 4. Pressure and flow waveforms taken from the 7200ae ventilator graphics package. Ventilator settings are the same as in Figures 1 and 2, with the exception of flow-triggering set to base flow of 8 L/min and flow sensitivity of 4 L/min. Monitored variables: exhaled tidal volume (V_T) 0.98 L, minute ventilation 9.8 L/min, respiratory rate 10 breaths/min, mean airway pressure 33.1 cm H_2O, and peak inspiratory pressure 60 cm H_2O.

How would you answer these questions?

Is the airway pressure waveform noticeably different from Figure 3?

Explain the flow waveform with special attention to end-exhalation.

Answers and Discussion on next page

Answers

Airway Pressure Waveform. In Figure 4, the airway pressure during the expiratory time remains stable. This suggests that the new base flow setting of 8 L/min is sufficient to maintain the PEEP-CPAP level while feeding the leak out of the chest tubes. The new flow sensitivity setting of 4 L/min is greater than the flow leaking out of the chest tubes as evidenced by the lack of autotriggering. Each of the breaths seen in Figure 4 are time-triggered, mandatory breaths delivered according to the set respiratory rate and inspiratory-to-expiratory-time ratio (I:E). The expiratory time is constant further confirming the absence of patient effort or autotriggering.

Flow Waveform. Expiratory flow returns to zero for nearly 3 seconds prior to the onset of the next breath. Close inspection of the last second of the expiratory flow waveform demonstrates a positive flow. This flow is equivalent to the flow leaking out the chest tubes and is required to maintain a constant PEEP-CPAP level. If the flow scale was reduced, the level of flow (leak) could be more accurately detected. In this instance the flow was approximately 3 L/min.

Discussion

This critically ill patient required massive fluid resuscitation and maximum levels of ventilatory support to maintain minimally acceptable hemodynamic and respiratory status. The massive trauma sustained by the patient resulted in severe liver damage, blood loss, and pulmonary contusion. In order to prevent hypotension, aggressive fluid administration was provided to restore intravascular volume, which resulted in deterioration of the patient's respiratory status and fluid accumulation in the lung. High levels of PEEP and peak airway pressure were necessary to maintain oxygenation. The pressures used are higher than those typically recommended to avoid volutrauma.[4,5] However, the fluid resuscitation resulted in a reduction in chest-wall compliance as well. This is evident as the measured intra-abdominal pressure of 25 mm Hg.

The initial problem in this case was caused by an air leak through the chest tubes, which was mistaken for patient-triggering. Differentiating between the leak and patient effort was particularly important in this instance because the nursing staff was titrating neuromuscular blocking agents to the presence of respiratory efforts. Train-of-four monitoring could not be used because massive tissue edema prevented adequate signal conduction.[2] The waveforms shown in this case further suggest patient effort due to the irregular respiratory pattern. Additionally, the ventilator assist light illuminated each time the PEEP fell below the pressure sensitivity setting, further suggesting that the patient was triggering breaths. The autotriggering caused by the leak created a situation in which the ventilator was required to deliver several breaths in rapid succession to maintain the set mandatory breath rate. This resulted in a shortened expiratory time, gas-trapping, and development of intrinsic PEEP.

Flow-triggering has been shown to reduce the work of breathing in laboratory and patient studies.[6-8] In this case, the continuous flow used for flow-triggering was used to overcome the air leak and maintain the set PEEP level. The initial base flow of 5 L/min was insufficient to overcome the leak and autotriggering continued. As the base flow was increased to 8 L/min, autotriggering was eliminated because the flow sensitivity was set greater than the leak rate. This is seen in Figure 4 in which, during the expiratory phase, flow becomes positive.

Critically ill patients require extensive monitoring and coordination of multiple therapies by physicians, respiratory care practitioners, and nurses. This case demonstrates the need for careful monitoring and communication between all bedside caregivers to optimize therapy and prevent ineffective and unnecessary treatment.

In this case, the patient's cardiopulmonary status continued to worsen, and she expired on post-trauma Day 4.

ACKNOWLEDGMENTS

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A RANDOMIZED CONTROLLED TRIAL COMPARING AN EXTENDED USE HYGROSCOPIC CONDENSER HUMIDIFIER (HCH) TO HEATED HUMIDIFICATION (HH) IN MECHANICALLY VENTILATED PATIENTS

Mann H Kollef, MD; M Oametta Clinkscale, RRT, Vanessa Boyd, RRT, Patricia Silver MEd, Ellen Trovillion, BSN, Pulmonary end Critical Care Division, Washington University School of Medicine, St. Louis, MO

Background: To compare a 7-day HCH (HMEE, Nellcor Puritan Bennett) to HH (MR730 Respiratory Humidifier, Fisher & Paykel Healthcare, New Zealand) using a heated wire ventilator circuit.
Method: Randomized controlled trial of HH vs HCH in a medical-aurgical ICU Patients with asthma, cystic fibrosis and purulent bronchiectasis were excluded Cross over from HCH to HH was allowed when copious secretions caused plugging of the HCH
Results: One hundred fifteen surgical and 82 medical patients requiring mechanical ventilation were randomized Five of 96 (5 2%) patients in the HCH group crossed over to the HH group due to copious secretions Eighteen (18 8%) HCH patients required mechanical ventilation for greater than 7 days

	HCH (n=96)	HH* (n=101)
Age, yr	58.3 ± 16 8	57 9 ± 17.0
APACHE II	17 2 ± 7 0	17 8 ± 6 4
MV, days	4 5 ± 5 5	3.7 ± 4 2
ETT occlusions, No (%)	0 (0 0)	0 (0 0)
Humidification Costs@, $	1064	3209
Death, No (%):	21 (22 1)	25 (24 7)
VAP, No (%):	9 (9 4)	11 (10.9)

(APACHE = Acute Physiology and Chronic Health Evaluation; MV = mechanical ventilation; VAP = ventilator-associated pneumonia; ETT = endotracheal tube); *P > 0.1 all comparisons
@ Costs include the costs of changing HCHs due to soilage and crossing over to HH in the HCH group

Conclusions: These data suggest that an extended use HCH may be a safe and cost-effective method of providing humidification to patients requiring mechanical ventilation

OF-97-005

ACCURACY OF FIVE PULSE OXIMETERS ON MECHANICALLY VENTILATED ICU PATIENTS.

Kelly Jager RRT, Colya Kaminiarz RRT, Dean Chittock MD.

Introduction: Pulse oximetry is so commonly used now that it is sometimes referred to as the 5th vital sign. Numerous studies have been conducted on their accuracy, however, many of these published studies have been carried out on healthy volunteers in a controlled setting. The primary purpose of this study was to compare the accuracy of 5 different pulse oximeters (Simed, Datex, Ohmeda, Nellcor 3000 and Nellcor 180) and secondarily to compare the Simed, our standard pulse oximeter already in-house, in relation to the others. **Methods:** One of the 4 other evaluation pulse oximeters was used in 4 different groups of mechanically ventilated ICU patients already having a Simed oximeter in place The 2 probes were randomly placed on patients fingers, and data recorded for pulse correlation, signal strength, and waveform quality. The SpO_2 from both pulse oximeters was recorded and an arterial blood gas drawn to determine the true HbO_2 The bias (SpO_2 - HbO_2) and precision (standard deviation of the mean difference) was recorded. **Results:** Results are shown in Table 1. The mean bias and precision for all 5 pulse oximeters was 3.8 ± 0.71 with a range in bias of 13 to 0. There was no difference in bias between oximeters There was, however, a statistical difference in bias between the different Simed oximeters used (8 different units compared to 1 of each of the other evaluation oximeters).

Table 1. Mean bias for 5 pulse oximeters

	Nellcor 180	Ohmeda	Datex	Nellcor 3000
n =	17	11	16	10
*patient HbO_2	0.87 - 0.99	0.92 - 0.99	0.92 - 0.99	0.84 - 0.99
bias & precision	4.06 ± 2.63	3.82 ± 1.08	3.56 ± 1 71	3.70 ± 3.23
Simed (b&p)	**2.29 ± 1.72**	**4.09 ± 2.34**	**3.81 ± 2.07**	**4.82 ± 2.56**

* range of HbO2's tested in each patient group
n= number of measurements taken in each patient group
b&p = bias & precision

Discussion: The accuracy of all 5 pulse oximeters was less than the manufacturers specifications when used in this limited number of critically ill, mechanically ventilated patients One device (Simed), when tested in 4 random patient groups, demonstrated a bias that varied from 2.29 to 4 82. Further study is needed to determine if this variability is related to a specific critically ill patient population.

OF-97-039

NON-BIAS FLOW TRIGGERING (NBFT) REDUCES INSPIRATORY WORK(WI) COMPARED TO PRESSURE TRIGGERING (PT) DURING PRESSURE SUPPORT VENTILATION

JA Alonso RRT; RH Kallet MS RRT; AR Campbell MD; DJ Morabito MPH, RC Mackersie MD. University of California, San Francisco at San Francisco General Hospital, Department of Surgery and Respiratory Care Services, San Francisco CA **Background:** In pressure support ventilation (PS) the W_I during the trigger phase depends upon the trigger threshold and associated time delay Flow Triggering (FT) has been found to decreased W_I compared to PT Unlike other FT systems, NBFT available on the Dräger Evita does not require a continuous base flow. We compared NBFT to PT during PS to assess if this new method of FT also reduces W_I. **Method:** A prospective, randomized cross-over study was conducted on 6 adult critical care patients with either Acute Lung Injury or Acute Respiratory Distress Syndrome. Static thoracic compliance was 30.2 ± 5.2 ml/cm H2O. Minute Ventilation (V_E) was 13.6 ± 5.6 L/min and Maximal Inspiratory Pressure was 46 ± 21 cm H2O. Comparisons with NBFT on the Evita were made using PT on the Hamilton Veolar (2 patients) and Siemen's Servo 900C (4 patients) Trigger level was set at 1L/min for NBFT and -0.5 cm H2O for PT PS level (8.7 ± 5.7 cm H2O) and PEEP (5.8 ± 2.08 cm H2O) were held constant between trigger systems. Measurements were performed with the BICORE CP-100 (Irvine, CA.) incorporating the Campbell Diagram. Wilcoxon Sign Rank Tests were used for statistical analysis **Results:** No significant differences were found between NBFT and PT respectively in either V_T (386 ± 52 vs.. 377 ± 18 ml), V_E (11.3 ± 3.9 vs 10.9 ± 10.9 L/min), peak inspiratory flow rate (58.3 ± 21.2 vs. 54.1 ± 27.5 L/min), inspiratory time (0.76 ± 0.15 vs. 0 77 ± 0.13) and respiratory drive (P0.1 = 5.0 ± 2.8 vs. 5.6 ± 2.9 cm H2O). Intrinsic PEEP was not found in any patient.

Variable	**PS-NBFT**	**PS-PT**
dPes (cm H2O)+	14.0 ± 12.9	17.6± 11 6‡
Pressure-Time-Product (cm H2O sec/min)	196.9 ± 80 4	256.2 ± 90.3‡
Total Work (joules/L)	1.19 ± 1.15	1.64 ± 0 98 ‡
Elastic Work (joules/L)	0.62 ± 0.69	0.89 ± 0.85 ‡
Resistive Work (joules/L)	0.57 ± 0.49	0.80 ± 0 47
Measured Sensitivity (cm H2O)*	3.22 ± 0.98	6.70 ± 2.20 ‡
Pressure Time Index	0.12 ± 0.06	0.18 ± 0.08 ‡

‡ $p < 0.05$
* Measured sensitivity = Minimum airway pressure required to initiate flow
+ dPes= Peak deflection from baseline esophageal pressures

Conclusion: During PS, NBFT significantly reduced inspiratory work and the index of muscle fatigue when compared to PT. The lower elastic work and measured sensitivity at comparable levels of V_T, inspiratory time and peak flow rate suggests that this was due to a reduction in imposed work during the trigger phase of inspiration. NBFT could benefit patients with low compliance, high V_E and elevated respiratory drive when minimizing imposed work is critical in preventing fatigue.

OF-97-027

INCREASE IN MEASURED AUTO-PEEP WITH THE APPLICATION OF FLOW TRIGGERING A PEDIATRIC CASE STUDY.

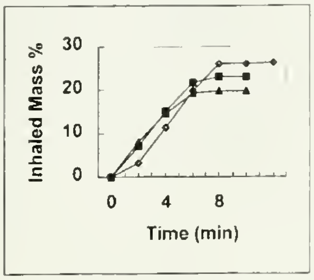
James E Martin BS, RRT, CPFT, Kay Urmetz RRT CPFT Kelli Chronister RRT Rashed Durgham MD, John Pope MD, Departments of Pulmonary Services, and Pediatrics MetroHealth Medical Center Cleveland OH

INTRODUCTION Incomplete exhalation between delivered breaths results in pulmonary gas trapping The term auto-PEEP has been used to describe this condition Physiologic consequences of trapped gas may result We report such changes when auto-PEEP is elevated during mechanical ventilation of a pediatric patient **CASE SUMMARY** A 6 y/o, 16 Kg former 24-week preemie with a history of BPD and tracheostomy was seen in the pediatric clinic for retractions wheezing and increased tracheal secretions for the previous 48 hours Physical examination revealed RR 36 HR 160, Temp 39° C, bilateral wheeze with decreased air exchange marked accessory muscle use and SpO_2 91- 93% on 30 FIO_2 Chest radiograph was remarkable for hyperinflation with perihilar bronchial thickening without infiltrates The patient was directly admitted to the PICU for fever and respiratory distress Supportive therapy included albuterol 2 5 mg Q2, intal 20 mg Q6, IV antibiotic, antipyretics and 30% heated humidified oxygen Within 24 hours the patient was transferred to the general pediatric floor On day 2 the patient s pulmonary status worsened and was readmitted to the PICU and started on albuterol 20 mg/hr (1 25 mg/Kg/hr), atrovent 250 mcg Q6, solumedrol Q6 During the course of the next two days the therapy was increased to albuterol 40 mg/hr (2 5 mg/Kg/hr), with the addition of continuous terbutaline infusion The decision was made to recannulate the patient with a cuffed trach tube and provide mechanical ventilator assistance Volume ventilation with a Nellcor Puritan Bennett 7200ae ventilator was initiated with patient effort controlled with doxacurium and ativan Three days after initiation of ventilator support the doxacurium was discontinued resulting in increased bronchospasms, airway leak, and a reduction in both exhaled tidal volume and SpO_2 With a gross airway leak the patient was changed to pressure control ventilation and subsequently re paralyzed There was a marked reduction in exhaled volumes Airway graphics demonstrated obstructed expiratory flow consistent with gas trapping A static auto-PEEP of 6 cm H_2O was measured using the ventilator software package Given this patient s history of chronic airway obstruction and previous demonstration of this problem the 6 L/m base triggering flow was discontinued A repeat auto-PEEP measurement of 2 cm H_2O was obtained To confirm the differences of auto-PEEP with and without flow triggering the measurements were repeated the next day with the same results In addition with the flow triggering on the expired tidal volumes were reduced from 140 ml to 50 ml with a decline in pulse oximetry from 93% to 88% No additional flow was introduced into the circuit that would bias the measurements **DISCUSSION** With this pediatric patient experiencing severe obstructed expiratory flows flow triggering using a base flow of 6 L/m resulted in an elevation of auto-PEEP a reduction in expired tidal volumes and desaturation as measured by pulse oximetry Although this may be an isolated incident, the option of using flow triggering on chemically paralyzed pediatric patients with severe expiratory airflow should be reviewed with each individual case

OF-97-042

ULTRASONIC NEBULIZATION WITH A CONTEMPORARY FLOW-TRIGGERED VENTILATOR. Michael McPeck BS RRT, Deniese S. LeBlanc BS RRT, Gerald C Smaldone MD PhD. Departments of Respiratory Care and Medicine University Medical Center, State University of New York at Stony Brook

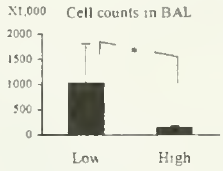
BACKGROUND: Prior to the advent of contemporary ventilators, delivery of aerosolized drugs during mechanical ventilation was relatively easy and the results were predictable. Using pneumatic nebulizers, driven by pneumatic circuits within the ventilator, our group previously found that aerosol delivery was generally similar among 3 popular brands of ventilator, and inhaled mass during a typical adult breathing pattern ranged from 9.6 to 14.7% (mean ±SD 13.0% ±1.8%) while treatment time averaged 30 min (McPeck, et al. Respir Care 1993;38:887-895). Some contemporary ventilators now depend on a constant bias flow in the ventilator circuit and upon "flow triggering" rather than pressure triggering to detect the beginning of a patient-initiated breath. However, flow introduced through a pneumatic nebulizer disables the flow triggering capability of the ventilator and interferes with the accurate measurement of exhaled volume. The Siemens Ultrasonic Nebulizer 345 (SUN) was developed to obviate this problem during mechanical ventilation with the Siemens Servoventilator 300 (SSV300). We designed this study to determine whether the SUN provides aerosol delivery equivalent to conventional pneumatic nebulizers. **METHODS:** Using a test bench protocol incorporating an SSV300, an ETT and a test lung, we measured the quantity of aerosol generated by 3 different SUNs charged with 3.0 mL of technetium (^{99m}Tc) radiolabeled unit dose albuterol solution. A low-resistance absolute filter was used to collect the radioaerosol delivered to the distal tip of the ETT, the quantity of which was expressed as a percentage of the nebulizer charge (inhaled mass %). A preliminary experiment confirmed that ^{99m}Tc behaved identically to albuterol in the SUN. Serial measurements over time of filter radioactivity were made with each nebulizer until cumulative radioactivity reached a plateau corresponding to the end of nebulization ("dryness"). **RESULTS:** Aerosol delivered to the ETT filter varied from 19.7 to 26.2% inhaled mass (Figure) with a mean ±SD of 23.0 ±2.6%. Each of the SUN units reached the plateau in 8 minutes. We did not observe interference with ventilator function during operation of the SUN. **CONCLUSION:** The SUN 345 exceeded the performance of typical pneumatic nebulizers from our previous study when used under similar conditions with the SSV300 ventilator and an adult breathing pattern. Aerosol delivery averaged 1.8 times greater (23.0% vs. 13.0%) while treatment time was reduced by a factor of 3.8 times (8 min vs. 30 min). In addition to improved aerosol delivery, we regard the absence of interference with flow triggering and monitoring as clinically significant.

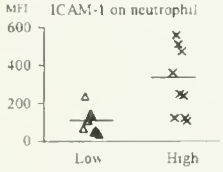


OF-97-066

NEUTROPHIL ACTIVATION AND ADHESION MOLECULES IN VENTILATOR-INDUCED LUNG INJURY. Hideaki Imanaka, MD, Motomu Shimaoka, MD, Noriyuki Ohta, MD, Masaji Nishimura, MD, Nobuyuki Taenaka, MD, Hiroshi Kiyono, MD, Nariaki Matsuura, MD. Surgical ICU, National Cardiovascular Center and ICU, Osaka University, Osaka, Japan.

Mechanical ventilation with high pressure/volume causes lung injury. Recent studies have demonstrated that a neutrophil-mediated inflammatory reaction is involved in the progression of ventilator-induced lung injury. We have hypothesized that adhesion molecule is increased in alveolar cells in such lung injury. **Methods:** Wistar rats were anesthetized with pentobarbital and tracheotomized. After muscular paralysis, they were ventilated for 40 min with pressure control mode, high (45 cm H_2O) or low (7 cm H_2O) peak inspiratory pressure (PIP). Zero PEEP and F_IO_2 of 0.21 were used in both PIPs. At 40 min of ventilation, arterial blood gas and static compliance were analyzed. After the animals were sacrificed, total lung lavage was performed. The number of neutrophil/ macrophage in lavage fluid and the expression of adhesion molecules (Mac-1, ICAM-1) on the cells were analyzed to access the degree of inflammation in the lungs. **Results:** In a high PIP group, PaO_2 decreased at 40 min (128 ± 24 mmHg at 5 min, and 45 ± 8 mmHg at 40 min), while in a low PIP group, a change in PaO_2 was not significant (100 ± 30 mmHg, 84 ± 15 mmHg). In a high PIP group, lower inflection points appeared in compliance curves (20.2 ± 2.9 cm H_2O). The high PIP group showed a significant increase in infiltrated neutrophils into alveolar spaces and upregulation of ICAM-1 expression on neutrophils.





Conclusions: Inflammatory reaction including upregulation of adhesion molecules may be involved in the formation of ventilator-induced lung injury.

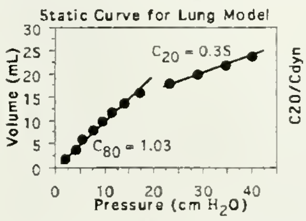
OF-97-091

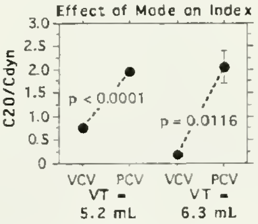
THE EFFECT OF VENTILATION MODE ON THE C20 /Cdyn INDEX OF LUNG OVERDISTENTION

Robert L. Chatburn RRT, Teresa Volsko RRT. Rainbow Babies & Childrens Hospital Cleveland, OH, MetroHealth Medical Center, Cleveland, OH.

Pulmonary volutrauma is a risk of mechanical ventilation that may be reduced if an appropriate index can be monitored. Fisher et al (Pediat Pulmonol 1988;5:10-14) have described an index of lung overdistention that is the ratio of compliance during the last 20% of inspiration to total dynamic compliance. A value of < 0.80 is consistent with lung overdistention. This index has been incorporated in at least one commercial monitor. Kano et al (J Appl Physiol 1944;77(3):1185-1197) found that the C20/Cdyn index was affected by the mode of ventilation. The purpose of this study was to test the hypothesis that the C20/Cdyn index changes with the mode of ventilation, independent of actual changes in lung overdistention.

METHOD: We used a lung model consisting of an elastic bellows (compliance = 1 mL/cm H2O) attached to a 3.0 ET tube. The bellows was inside a rigid walled cylinder with a piston. The position of the piston could be changed to contact the expanding bellows at different points in inspiration. There was one compliance before the bellows touched the piston and a smaller compliance after, simulating overdistention. A PV curve for the model was created with a calibrated syringe and a water manometer. The model was ventilated with a neonatal ventilator (Bear BP200) in either the volume controlled (VCV) mode (time triggered, flow limited, time cycled) or pressure controlled (PCV) mode (time triggered, pressure limited, time cycled) at the same tidal volume. Two tidal volumes were examined, one just below and one just above that required for the bellows to touch the piston (ie, with and without simulated lung overdistention as demonstrated on pressure-volume loops). Three sets of data were collected for each tidal volume using a BICORE C-100 neonatal monitor. Mean values for C20/Cdyn were compared with paired t-tests. **RESULTS:** C20/Cdyn data is mean ± SD in figure below





The C20/Cdyn index increased by switching to PCV even though volume and overdistention were constant. **CONCLUSION:** Presence of a pressure plateau during pressure controlled ventilation masks overdistention. The index is most accurate with constant flow inspiration.

OF-97-106

ESOPHAGEAL PRESSURE IS A POOR ESTIMATE OF REGIONAL PLEURAL PRESSURE BUT A FAIR SURROGATE FOR MEAN PLEURAL PRESSURE IN SUPINE DOGS. McKibben A, Adams A, Goldner M, Marini J J. Univ. of Minnesota & St. Paul Ramsey Medical Center, Mpls/St. Paul, MN. **Background:** Measurement of esophageal pressure (Pes) provides an estimate of pleural pressure (Ppl), allowing determination of transpulmonary pressure (P_{TP}). Assessment of P_{TP} may guide ventilatory strategy to avoid pressure or volume induced lung injury and permits partitioning of respiratory system mechanics into lung and chest wall components. Direct measurement of Ppl would be ideal, but this would require a surgical procedure to place a pressure sensing device within the pleural space. P_{ES} provides a minimally invasive estimate of pleural pressure, although it is susceptible to artifacts and can not reflect the range of pleural pressure. In a study which included direct measurement of regional pleural pressure, we also measured P_{ES} to determine its relation to Ppl. **Methods:** Eight mongrel dogs were anesthetized and sedated in the supine position. Three specially designed pressure sensing wafers were placed via a right thoracotomy, equally spaced along the fifth intercostal line (ventral, middle, dorsal). The incision was closed and a chest tube evacuated air from the pleural space. A multiperforated esophageal balloon catheter was placed in the usual manner. The ventilator was set to deliver a range of tidal volume at two levels of PEEP (4.8±0.99-LOW and 15.1±0.85 cm H_2O-HIGH, mean±1 S.D.) **Results:** . End expiratory values of P_{ES} are compared to Ppl at ventral, middle, and dorsal locations. Values are cm H_2O, mean±1 S.D.

	P_{ES}	Ventral	Middle	Dorsal	Mean Ppl
PEEP Low	5.1±1.9	-1.0±2.1	2.9±2.9	7.3±2.8	3.0±1.6
PEEP High	8.7±1.8	4.1±2.6	7.9±3.7	11.7±2.7	7.9±2.5

Correlation Coefficient (r^2)	Ventral	Middle	Dorsal	Mean
P_{ES}	0.4744	0.3126	0.2787	0.500

Conclusions: P_{ES} has a relatively poor correlation with directly measured regional Ppl. The relationship is, however, closest between Pes and the mean Ppl. While esophageal pressure measurement is valuable as a clinically feasible means of sampling Ppl, its limitations must be appreciated, e.g. when estimating Ptp. Because this investigation did not assess Pes during spontaneous respirations, these findings do not directly relate to the use of Pes for determination of the work of breathing.

OF-97-136

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SYRINGE TECHNIQUE FOR STATIC VOLUME-PRESSURE (VP) CURVES IN ARDS.

Carl Haas, MLS, RRT*, Lauren Stapp, RRT*; Linda Folk, RRT*; Daneile Mascheroni, MD+; Robert Bartlett, MD# Critical Care Support Services* and the Department of Surgery# University of Michigan Health System, Ann Arbor MI; University of Milano, Milan Italy+

Introduction: Static VP curves may help adjust ventilators. Although recommended that PEEP be set above the lower inflection point (LIP) and that tidal volume or inflation pressure be limited to below the upper inflection point (UIP), the super-syringe technique (SST) of determining LIP and UIP has mainly been a research technique which many RCP's are not familiar with. Our study objectives were to: 1) determine SST safety; 2) determine the difference in LIP using 50 mL vs 100 mL incremental inflation steps; and 3) compare agreement of set PEEP with LIP and plateau pressure with UIP. **Methods**: Initially 2 ECMO patients were studied to ensure they would not decompensate during the procedure. In total 27 studies were performed on a convenience sample of 7 ARDS patients (3 ECMO, 4 non-ECMO). Either a 1.0 L or a 3.0 L super-syringe (calibrated in 20 mL or 100 mL increments, respectively) was connected in series to a filter, a pressure sensing port and patient connector. Pressure was transduced using the bedside hemodynamic monitoring equipment (Marquette Series 7000, Milwaukee WI) and continuously graphed. Prior to study, patients were determined to have no airleak, no respiratory effort (paralytic agent given if necessary), and to be hemodynamically stable. Baseline HR, BP, SpO2, SvO2 (if available), continuous cardiac output (if available), and ventilator settings were recorded while receiving an FIO2=1.0. HR, BP, SpO2, SvO2 and CCO were observed during and recorded at the end of the procedure. Duration off the ventilator was recorded. Test procedure was: fill syringe with pure oxygen; disconnect ventilator and start timer; allow 15 seconds for complete exhalation; attach super-syringe (disconnect and reattach if pressure sensed); inject either 50 or 100 mL volume; wait 2-3 sec and inject another volume; repeat until either 1.5 L, 50 cm H2O or maximum volume of syringe attained or patient decompensated (rise in HR≥20, drop in BP ≥20 mmHg or drop in SpO2 to 80%.) **Results**: *Objective 1:* No study was stopped due to patient decompensation. The table shows that although SpO2 was statistically reduced, no clinically relevant changes occured in any measured parameter. Total duration off the ventilator was 77.4 ± 16.1 sec (range 56-115 sec).

	HR	Mean BP (mmHg)	SpO2 (%)	SvO2 (%)	CCO (L/min)
Pre	110 ± 18.1	84.5 ± 10.1	95.1 ± 3.5	80.3 ± 5.8	9.6 ± 2.5
Post	109 ± 17.9	89.0 ± 16.8	93.6 ± 4.3	79.6 ± 6.6	9.7 ± 2.6
p / n	0.397 / 27	0.064 / 27	0.006 / 27	0.415 / 20	0.65 / 7

Objective 2 For LIP, although more accurate using 50 mL steps, there appears to be minimal clinical difference when directly comparing 50 vs 100 mL inflations (12.4 ± 3.4 vs 13.8 ± 4.7 cm H2O, p=0.206, n=7) or when extrapolating 100 mL inflation LIP from the 50 mL inflation curve (12.6 ± 3.8 vs 14.0 ± 4.0 cm H2O, p=0.0003, n=14). *Objective 3:* PEEP was generally set below LIP (10.1 ± 1.7 vs 12.6 ± 3.9 cm H2O, p=0.009). Only 9 of 27 studies (4 of 7 patients) showed an UIP. Although the mean UIP was 33.1 ± 5.4 cm H2O (range 26.5 to 42.0) and plateau was 34.6 ± 4.7, UIP was less than plateau by ≥5 cm H2O in three cases. **Conclusions**: 1) The procedure can be safe, provided close monitoring is maintained; 2) LIP is most accurately determined with 50 mL steps; 3) PEEP may be under applied in many patients; 4) unrecognized overdistension may occur.

OF-97-154

Measurement of Spontaneous Breathing Parameters in Mechanically Ventilated Patients: Does Resting Period between Measurements Make Difference?

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Introduction: Spontaneous breathing parameters such as Pimax, $\dot{V}$E, RR, calculated Vt and RSI are the usual criteria for weaning from mechanical ventilation, but the sequence of these measurements differs. Some clinicians measure Pimax first and then $\dot{V}$E and RR (Method A) to get the highest Pimax. Others measure $\dot{V}$E and RR first (Method B) because this way is easier to perform and less stressful. In whatever sequence, there is conventionally no resting period between two measurements except in case that signs of distress occur. Our previous study found that Method A got higher $\dot{V}$E and RR values and induced fewer adverse reactions than Method B but there was no significant difference in Pimax data*. We doubt whether this difference is due to the absence of resting period between two measurements. **Methods:** Using Method A and B, 91 sets of spontaneous breathing parameters were measured in 91 adult mechanically ventilated patients who were in stable condition. In randomized choice of sequence, Methods A and B were conducted at least 10 minutes apart to ensure that the patient condition returned to baseline (SaO2 ± 2%, PR ± 10/min). In each method, between measurements of Pimax and VE/RR, the patient was re-connected to the ventilator until his/her condition returned to baseline and recorded the length of duration. Oxygen saturation, PR and breathing pattern were monitored before, during and after each measurement. Adverse reactions were defined as (1) PVC ≧ 5/min if patient with EKG monitor, (2) HR increase over 20/min from baseline, (3) HR decrease over 20/min from baseline, and (4) desaturation (SaO2 < 85%). Paired-t or Wilcoxon signed-ranks test was used to compare the data from different methods. Multiple regression was applied to control the confounding effects. Chi-square test was used to compare the difference in incidence of adverse reactions. A $p < 0.05$ was considered significant. **Results:** The medium resting duration for the patient to return to baseline condition was 40 seconds in Method A (range: 0 - 240 sec) and 30 seconds in B (range 0 - 240 sec). After controlling the confounding effects of age, history of neuromuscular and cardiac diseases, the patient's conscious level significantly influenced all 5 spontaneous breathing parameters, sex influenced $\dot{V}$E and Vt, and with or without COPD influenced RSI. There was no significant difference in any parameter measured by Method A and B. The incidence of adverse reactions differed not much as well (16.48% in A vs 14.29% in B). **Conclusions:** The results of spontaneous breathing parameters and the incidence of adverse reactions made no difference in whatever sequence they were if adequate resting period was provided between measurements. This finding can persude the clinicians to modify their techniques in clinical practice.

*Bien MY, Chu CC, Wang JH, Chen JR, Lin IN, Jou SB. Measurement of Spontaneous Breathing Parameters in Mechanically Ventilated Patients. A Comparison of Two Methods. Respir Care 1992 37 1352

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PRELIMINARY ANALYSIS PREDICTING ARTERIAL CO2 IN POST OPERATIVE CORONARY ARTERY BYPASS PATIENTS

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Background: Endtidal CO2 (ETCO2) monitoring is commonly used on ventilated patients in acute care, yet ETCO2 is not relied upon for precise data. Main factors affecting PaCO2-ETCO2 gradient (Pa-ETCO2) for intubated patients are deadspace and airway obstruction. If coronary artery bypass (CABG) patients have stable deadspace and no acute airway obstruction, Pa-ETCO2 may remain relatively constant for each sequential arterial blood gas (ABG) while the patient is intubated. **Hypothesis:** We wanted to analyze the change in Pa-ETCO2 of sequential ABG's for intubated CABG patients. **Methods:** We prospectively studied post-op CABG patients with ETCO2 monitoring and collected ABG results for a one month period. Copies of ETCO2 waveforms were also collected and analyzed. Pa-ETCO2 was calculated for each ABG. The change in Pa-ETCO2 (ΔPa-ETCO2) was calculated for each pair of sequential ABG's on each patient. Duration between sequential ABG's was uncontrolled (range, 2 to 21 hours). Only patients with "normal" (not obstructive) ETCO2 waveforms were analyzed (waveforms that have expiratory plateau). **Results:** Fourteen CABG patients had "normal" waveforms and were included in the study. A total of twenty six pairs of sequential ABG's were identified and included.

Data from 14 CABG patients having sequential pairs of ABG's:

	n	Avg ± Std Dev
PaCO2, torr	52	36.81 ± 6.47
ETCO2, torr	52	28.44 ± 5.94
Pa-ETCO2 of each ABG, torr	52	08.37 ± 2.96
ΔPa-ETCO2 of each pair of sequential ABG's, torr	26	00.27 ± 1.80

Conclusions: The average Pa-ETCO2 fluctuates by 8.37 ± 2.96 torr in this population of CABG patients with normal ETCO2 waveforms. However, in this group of patients, the average ΔPa-ETCO2 of sequential ABG's in each individual patient only fluctuated 0.27 ± 1.8 torr. These results show that with each PaCO2, the next PaCO2 could be predicted within 0.27 ± 1.8 torr without an ABG drawn. These results could help to safely decrease utilization of ABG's for this population of patients.

OF-97-170

NEBULIZED PROSTACYCLIN; AN ALTERNATIVE TO NITRIC OXIDE FOR TREATING PULMONARY HYPERTENSION IN AN INFANT.

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Pulmonary hypertension is often a life threatening complication of severe bronchopulmonary dysplasia Inhaled nitric oxide (NO) has gained acceptance as a selective pulmonary vasodilator, however, specialized equipment is required for its delivery, making its use impractical for many institutions. Prostacyclin is a more obscure vasodilator, that when inhaled, can be selective for the pulmonary vasculature due to its short half-life (3 min). We report a case of an infant with pulmonary hypertension as a complication of severe bronchopulmonary dysplasia NO administration was unavailable at our institution at the time of his hospitalization We administered prostacyclin via a Heart (Vortran Medical Technology, Inc. Sacramento CA) continuous nebulizer through a ventilator circuit on two separate occasions during his prolonged course. Like any nebulized medication, precise dosing is difficult to estimate. We used a medfusion syringe pump (medexinc.Duluth, GA) for prostacyclin delivery and an IV pump (Lifecare 5000, Abbott. Chicago IL) to maintain a constant level of normal saline within the nebulizer. The initial course of nebulized prostacyclin (dose: 6.5 ng/Kg/min) showed dramatic improvement Peripheral perfusion went from poor, with cold pale extremities to an immediate improvement in color and temperature. PaO2 increased from 47mmHg to 150mmHg within 15 minutes. Prior to prostacyclin administration, the patient was being treated with intravenous prostaglandin E1 (PGE). The combination of this medication with prostacyclin resulted in systemic hypotension, suggesting systemic effects of inhaled prostacyclin The PGE was quickly weaned and discontinued 20 minutes after nebulization began. Ventilator (Siemens Servo 900C) settings before initiating prostacyclin nebulization were: PC rate 40, PIP 28, PEEP 8, with FIO2 variable, approximately 70%. Within 2 days of continuous nebulization, settings were weaned to rate 28, PIP 26, PEEP 8, and FIO2 .40 The initial course of prostacyclin continued for 11 days, then was discontinued due to patients improved respiratory status Over the next few weeks, he required increasing ventilatory support. Another course of prostacyclin was initiated without the dramatic improvement initially witnessed. He was then transferred to a center with NO and ECMO The ability to deliver prostacyclin via continuous nebulization, using equipment found in almost any RC department makes it a viable alternative to NO for pulmonary vasodilation.

OF-97-061

AN INNOVATIVE APPROACH TO REFLECT SPLANCHNIC PERFUSION USING AN INDWELLING CONTINUOUS ARTERIAL BLOOD GAS MONITORING SENSOR

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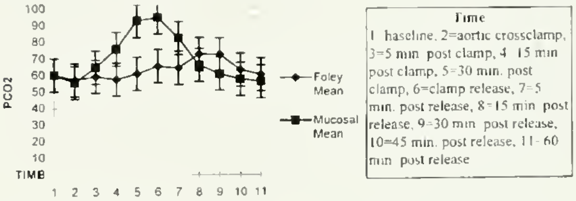
Background Splanchnic hypoperfusion has been shown to predict multiple organ failure secondary to severe circulatory shock. The resulting tissue ischemia provides an index of mortality and morbidity in critically ill trauma patients and several other populations, including those that undergo cardiopulmonary bypass (CBP) CBP has been associated with splanchnic ischemia and subsequent multiple organ failure. Inconsistent reproducibility of calculated intramucosal pH via gastric balloon tonometry limits its reliability in the clinical setting. This study offers a novel approach to reflect splanchnic perfusion by using a continuous arterial blood gas monitoring sensor as an alternative to gastric balloon tonometry It was hypothesized that the bladder functions as a tonometer, thereby allowing PCO_2 to be monitored in the urine. **Methods** A group of four anesthetized pigs were studied. Total hemoglobin and arterial PCO_2 was maintained in normal range Two separate calibrated Paratrend 7 (Diametrics Medical, Inc) sensors were placed via bladder cystotomy side by side with one sensor abutting the bladder mucosa, the other placed inside a 30 Fr Foley catheter The tip of the sensor was positioned proximal to the urine inlet port such that no part of the sensor was in direct contact with bladder mucosa. Baseline measurements were established. The aorta was cross-clamped and PCO_2 measurements were obtained at time intervals of 0, 5, 15, and 30 minutes. The cross-clamp was then released and PCO_2 measurements were made again at time intervals of 0, 5, 15, 30, 45, and 60 minutes **Results** The data suggests that bladder mucosal PCO_2 is a responsive indicator of hypoperfusion during interruptions in blood flow induced by aortic cross-clamping The sensor positioned inside the Foley catheter was less responsive and displayed a delayed response once the cross-clamp was released



Conclusion: Bladder mucosal PCO_2 appears to be a responsive indicator of splanchnic hypoperfusion The bladder mucosal PCO_2 sensor displayed a sensitive response to fluctuations in PCO_2 as compared to Foley PCO_2 Irrespective of the small sample size, the delayed response rise in Foley PCO_2 after release of the cross-clamp indicates a need for further study A Foley catheter design permitting direct monitoring of bladder mucosal PCO_2 could provide a simple and continuous means to trend splanchnic hypoperfusion

OF-97-063

SURVANTA IN ARDS: A PEDIATRIC CASE REPORT

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The delivery method of exogenous surfactant has previously been studied Clinical application of exogenous surfactant delivery has indicated that the traditional amount of surfactant needed for instillation, in patients outside of the neonatal population, may be prohibitive It has been established that surfactant dysfunction/inactivation is a prominent feature in the pathophysiology of Adult Respiratory Distress Syndrome (ARDS), suggesting that exogenous surfactant may be advantageous in this patient population In this case, a 16 month old, 11 kg child, with a history of prematurity, was admitted to our Pediatric Intensive Care Unit in respiratory failure He was mechanically ventilated on the Servo 300 and over the course of 3 days, required progressive escalation in support due to the development of ARDS At this time, he was in the Pressure Regulated Volume Control (PRVC) mode , FiO_2 of 65, PIP 45 cmH_2O, PEEP 10 cm H_2O, Paw 28 cm H_2O, and a V_E of 296 cc/kg/min to maintain normal ventilation and acceptable oxygenation The decision was made to administer Survanta in a further attempt to optimize lung function Four ml/kg of Survanta was delivered through a catheter measured 0 5 cm H_2O distal to the tracheal tube The patient received 1 0 FiO_2 and was positioned as per manufacturer's recommendations during the procedure

Results Data was collected by use of the Bicore bedside pulmonary function monitor and is as follows

	Before	30 minutes after	2 hours after
PaO_2/FiO_2	110	185	171
C_L(ml/kg/cm H2O)	1	1	2
A-a DO_2 (mmHg)	278	206	184

A sustained favorable response was realized by the improvement of PaO_2/FiO_2 by 36%, C_l by 50% and A-a DO_2 by 34% two hours after the completion of Survanta delivery Understanding that ARDS is a progressive disease, redosing was performed at 12 hour intervals until progressive improvement ceased to be evident This patient received 3 total doses He continued to wean and was extubated 7 days after initial dosing He was discharged to home 4 days later in his usual state of health

Conclusions This method of exogenous surfactant administration seemed to be valuable in the treatment of this pediatric patient with ARDS

OF-97-069

HIGH FREQUENCY OSCILLATORY VENTILATION IN ARDS: A CASE STUDY

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Patinet Data and Case Summary: This is a 5.5 kg, six month old infant, with a history of prematurity, gastroschisis, hyperalimentation hepatitis, ileal resection, multiple bowel resections and recurrent sepsis, who was admitted to our institution for nutritional rehabilitation. During this admission, the patient underwent a liver biopsy and colostomy closure. Subsequently, he developed sepsis and was transferred to our Pediatric Intensive Care Unit for further management He quickly deteriorated to requiring intubation and mechanical ventilation Medications delivered continuously at this time included dopamine, dobutamine and morphine Chest x-ray revealed dense consolidation of the left upper lobe and patchy infiltrates throughout the remainder of the lung fields Abdominal findings demonstrated that bowel loops were central and the flanks were bulging suggesting the presence of acites, further compromising our already challenged method of mechanical ventilation One day post op, the patient progressed to Adult Respiratory Distress Syndrome Permissive hypercapnea and PaO_2 greater than or equal to 50 mmHg became acceptable. In order to achieve this goal, the patient was paralyzed and placed on Pressure Regulated Volume Control via the Siemens Servo 300. PEEP +10 cmH_2O, mean airway pressures (MAP) 26-31 cm H_20, peak pressure +47 cm H_20, V_E 220 ml/kg/min were necessary in order to maintain gas exchange At this time, in the face of persistent acidosis, A-a DO_2 of 504-554 mm Hg, and hypoxemia, PaO_2/FiO_2 of 57, it was decided to place the patient on the Sensor Medics Oscillator 3100A Initial settings were 10 Hz, 33% inspiratory time, MAP 34, amplitude 40 Two hours later, the PaO_2/FiO_2 was 182 with A-aDO_2 of 272 This realized benefit continued into the evening and throughout the patients ventilator course Sixteen hours after being placed on the oscillator, the patient's PaO_2/FiO_2 was 167 and his A-a DO_2 was 195 mm Hg Twenty hours later, the patient continued to wean While on MAP of 21 cm H_20, $Pa0_2/Fi0_2$ was 289 with A-a DO_2 66 of mmHg During this time frame, dopamine and dobutamine infusions were successfully weaned Chemical paralysis and sedation continued The following chart summarizes changes in ventilation parameters

Mechanical ventilation hours	Mode	MAP	$Fi0_2$	$Pa0_2/Fi0_2$	A-a$D0_2$
8	*SIMV/PC*	*26-31*	*1*	*53*	*524*
16	*HFOV*	*34*	*0 65*	*182*	*271*
29	HFOV	28	0 43	167	195
49	HFOV	21	0 27	289	66

Significance of the Case: High Frequency Oscillatory Ventilation appeared to be valuable in the treatment of this patient. This method of mechanical ventilation enabled the healthcare team to improve oxygenation and ventilation of this pediatric patient with ARDS

OF-97-070

RESPIRATORY COMPLICATIONS AFTER EXTENDED DIRECT ANASTOMOSIS FOR NEONATAL AORTIC ARCH ANOMALY.

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Respiratory complications are common after extended direct anastomosis for neonatal aortic arch anomaly. However, there has been no report about the incidence. The purpose of this study is to evaluate the incidence and prognosis in such patients

SUBJECTS AND METHODS: Subjects were 31 consecutive neonates (age < 28 days) who underwent extended direct anastomosis for neonatal aortic arch anomaly (18 with coarctation of the aorta and 13 with interruption of aortic arch) in our institute from 1992 to 1996. By a retrospective chart review, we investigated respiratory complications, prognosis, preoperative and postoperative ventilatory support.

RESULTS: Age and weight were 11.8 ± 6.9 (mean ± SD) days and 2.82 ± 0.49 kg at the repair surgery, respectively. The mortality in ICU was 29% and that in hospital was 32% Twelve neonates (39%) had required mechanical ventilation before the surgery because of congestive heart failure or deteriolating acidosis. The neonates who required mechanical ventilation before surgery showed significantly higher mortality than those who did not (58% vs 11%, $p < 0.05$). Twenty-four patients (77%) had postoperative respiratory complications; atelectasis (n=13), pneumothorax (n=8), pleural effusion (n=7), stenosis of the left main bronchus (n=6), phrenic nerve palsy (n=5), airway bleeding (n=4), and chylothorax (n=3). Postoperative intubation period was longer in patients with respiratory complications than in those without (37 ± 54 vs 9 ± 9 days, $p<0.05$).

CONCLUSION: Respiratory complications were common in neonates with aortic arch anomaly after extended direct anastomosis The patients who developed respiratory complications needed longer ventilatory support.

OF-97-092

SURFACTANT WITH PARTIAL LIQUID VENTILATION IMPROVES LUNG PATHOLOGY IN AN ANIMAL MODEL OF IRDS.

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Introduction: Partial liquid ventilation (PLV) with perflubron (LiquiVent®) in neonates is currently being studied in many centers Does the administration of exogenous surfactant (Survanta®) with PLV dramatically change the pathology of the lung with IRDS? In this study, histologic and morphometric analysis were performed on a neonatal lung injury animal model following surfactant and PLV administration.

Method: 32 newborn piglets (1.51± 0.38 kg) were sedated, intubated and ventilated with tidal volume of 15 cc/kg. We induced lung injury with repeated saline lavage, defined as $PaO2<60$ torr at FiO2 1.0, with a reduction of lung compliance by 30%. The piglets were randomized into 4 groups and treated for 2 hours with: 1) surf only (S; n=8); 2) PLV only (PLV; n=8); 3) PLV followed by surf (PLV-S; n=8 and 4) surf followed by PLV (S-PLV; n=8). 7 histologic variables (alveolar and interstitial inflammation and hemorrhage, edema, atelectasis and necrosis) were scored on a 0-4 point scale (no injury = 0, injury in 25% of field = 1, injury in 50% of field = 2, injury in 75% of field = 3, and injury throughout field = 4). Morphometric analysis on trichrome-stained slides analyzed total cellular to air space, expressed as percent tissue area (% tissue area = [cellular area/total area] X 100). Kruskal-Wallis, Wilcoxin, and paired t-tests with Bonferroni correction ($p<0.05$) were used to assess differences .

	Histology Total injury score		Morphometrics Mean % tissue area	
	upper	lower	upper	lower
S	4.75±2.30•	5.20±2.10••	46.5±8.3†	45.2±8.1††
PLV	4.55±2.15	2.50±1.30	39.0±8.7	30.9±7.8
PLV-S	3.90±1.65	2.85±2.00	35.9±6.4	30.0±7.6
S-PLV	2.65±1.10	2.65±1.30	33.9±8.2	30.0±6

•$p<0.05$ S vs S-PLV, ••$p<0.05$ S vs all, $^{\dagger}p<0.03$ S vs PLV-S, S-PLV, $^{\dagger\dagger}p<0.002$ S vs all

Conclusion: In this animal model of neonatal RDS, surf followed by PLV improved lung pathology more consistently than PLV or surf alone, or PLV followed by surf (Liquivent® supplied by Alliance Pharmaceutical Corp and Hoechst Marion Roussel, Survanta® supplied by Ross Laboratories, Inc)

OF-97-094

PARTIAL LIQUID VENTILATION WITH SURFACTANT DURING HIGH FREQUENCY AND CONVENTIONAL VENTILATION IN AN ANIMAL MODEL OF IRDS.

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We compared oxygenation effects of high frequency oscillatory ventilation (HFOV SensorMedics 3100) and conventional ventilation (CV Drager Babylog) in 19 newborn piglets (1.78 ± 0.12 kg) with saline lavage-induced lung injury ($PaO2<60$ torr at FiO_2 1.0 and 30% decrease in C_L) treated with surfactant (S Survanta®) and partial liquid ventilation (PLV LiquiVent®) After lung injury, piglets randomly received either HFOV (n=10) or CV (n=9) Ventilator settings after lung injury for the HFOV group FiO_2 1.0, frequency of 10 Hz, ΔP to maintain injury level PCO_2, mean airway pressure (Paw) 2 cm H_2O more than previous on CV and CV group FiO_2 1.0, IMV 40/ min , PEEP 4 cm H_2O, V_T 15 mL/kg All animals then received 4 mL/kg of S 30 minutes later, perflubron was intratracheally instilled to FRC level At 1 hr PEEP and Paw were increased until there was no further increase in PaO_2 After optimizing Paw, we maintained PaO_2 100-150 torr by first decreasing FiO_2 to as low as 0.4, then lowering Paw or PEEP and kept $PaCO_2$ 35-50 torr We recorded arterial blood gases every 30 minutes for 4 hours

Results Oxygenation improved with CV after S and with HFOV only after S followed by PLV Data are mean ± SE ANOVA and paired t-tests assessed differences ($p<0.05$)

	CV group			HFOV group		
	Paw	a/A	OI	Paw	a/A	OI
Before injury	6.5±0.2	0.81±0.03	1.2±0.1	6.8±0.2	0.81±0.03	1.3±.1
After injury	13.9±0.4*	0.08±0.01*	26.8±1.9*	14.1±0.7*	0.07±0.01*	33.0±3.8*
On CV/ HFOV	13.9±0.4	0.08±0.01††	26.8±0.9†	15.8±1.1	0.08±0.01	35.4±5.0
After S	12.4±0.5	0.42±0.07$^{\Delta}$	8.6±3.1$^{\Delta}$	15.2±1.3	0.09±0.01	27.8±3.4
S+PLV	12.3±0.4$^{\Delta}$	0.42±0.07$^{\Delta}$	6.9±1.9$^{\Delta}$	15.9±1.0	0.23±0.06†	15.9±2.8
at 4 hours	12.8±0.9$^{\Delta}$	0.45±0.02	4.8±0.9	17.0±1.2	0.52±0.05	6.1±0.7

*$p<0.05$ before vs after injury $^{\Delta}p<0.05$ CV vs HFOV $^{\dagger}p<0.005$ after S vs S+PLV (HFOV)

$^{\dagger\dagger}p<0.05$ after S vs On CV

Conclusions Surfactant and PLV during both CV and HFOV dramatically improves oxygenation in this neonatal RDS model, however, HFOV requires a higher Paw for similar effect Initial surfactant response may be different between the two modes of mechanical ventilation (LiquiVent® supplied by Alliance Pharmaceutical Corp and Hoechst Marion Roussel Survanta® supplied by Ross Laboratories Inc)

OF-97-095

USE OF HEAT & MOISTURE EXCHANGERS TO REDUCE PERFLUBRON EVAPORATIVE LOSS IN PARTIAL LIQUID VENTILATION IN SWINE.

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Partial liquid ventilation (PLV) is in clinical trials as a treatment for patients with acute respiratory distress in which the lungs are filled with *LiquiVent*® (sterile perflubron, Alliance Pharmaceutical Corp and Hoechst Marion Roussel) while on conventional mechanical ventilation (CMV) We hypothesized that the use of a heat & moisture exchanger (HME) in PLV would retard perflubron evaporative loss and thereby minimize redosing requirements. In this study, two HMEs (Baxter HEPA/HCH and Hudson RCI AQUA+ FH) were evaluated for safety (pressure drop, ΔP, across HME and development of auto-PEEP) and efficiency to retain expired perflubron vapor (compare volume of perflubron evaporated with and without HME). Swine (37-48 kg) were anesthetized, paralyzed, and ventilated with measurement of hemodynamics and lung mechanics at baseline and during 5 h of PLV or CMV (TV = 13 mL/kg, RR = 20/min, I E = 1 2.3 PEEP = 10 cm H_2O) There were five animal groups. Hudson-PLV (n=13), Hudson-CMV (n=10), Baxter-PLV (n=8), Baxter-CMV (n=7), and PLV only (n=11). PLV animals received 30 mL/kg perflubron and evaporative loss was calculated as expired minute ventilation times the concentration of expired perflubron as measured by a specialized infrared absorption technique. The ΔP across each HME was determined before (dry) and after 5 h of animal ventilation using an *in vitro* apparatus (ISO 9360 specifications) with flow rates of 30, 60, and 90 L/min Results for perflubron evaporative loss and HME ΔP at 60 L/min (expired flow direction) are shown in table (mean ± SEM) PLV did not significantly affect the ΔP

	Perflubron Evaporative Loss (mL/kg/h)	ΔP (cm H_2O)	
		before use	after use
Hudson-PLV	0.74	1.2 ± 0.1	1.2 ± 0.1
Hudson-CMV	N/A	1.3 ± 0.1	1.3 ± 0.0
Baxter-PLV	0.61	2.5 ± 0.1	2.6 ± 0.1
Baxter-CMV	N/A	2.5 ± 0.1	2.5 ± 0.1
PLV only	1.15	N/A	N/A

There were no significant differences among HME groups in terms of hemodynamic or lung mechanics parameters and further, there was no development of auto-PEEP We conclude that HME use with these devices during PLV is safe and reduces evaporative loss by about 35-45% depending on choice of HME

OF-97-099

THE EFFECT OF VENTILATORY MODE AND INSPIRATORY TIME ON GAS EXCHANGE DURING PARTIAL LIQUID VENTILATION (PLV) IN AN ACUTE LUNG INJURY MODEL

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Perflubron acts as liquid PEEP, and has been shown to be an effective way for improving oxygenation in the injured lung. However, little information is available about different ventilation modes during PLV We evaluated the efficiency of pressure controlled (PCV) and volume controlled (VCV) ventilation at various I:E ratio during PLV

Methods Five sheep weighing 26.3±2 6kg had acute lung injury induced by warm saline lavage, followed by filling with 30mL/kg perfluhron. Baseline ventilation was provided with a PB7200, VCV, rate 15/min, V_T 12mL/kg, I E 1.2, F_IO_2 0.5 with PEEP set above the lower inflection point (LIP) on the pressure-volume (P-V) curve VCV and PCV at 1:2, 1:1 and 2:1 I E were compared in random order During all modes V_T (VCV) and PIP (PCV) were adjusted to maintain a constant P_{PLAT} and total PEEP was kept constant.

Results PaO_2 did not change significantly among modes. V_D/V_T during VCV 1.1 and VCV 2.1 was lower than during PCV 1:2 No hemodynamic differences were observed

	POST	VCV1.2	VCV1.1	VCV2:1	PCV1:2	PCV1 1	PCV2.1
PaO_2	80±7	94±5	96±16	95±12	92±7	84±7	92±11
TV(mL)	348±33	332±15	339±28	352±34	313±38	322±40	355±59
VD/VT	.58±.04	.51±.05	.49±.08*	49± 04*	58±.05**	.52± 05	51±0 05
CO(L/m)	4 4±0.6	4 6±1.3	4 5±1.0	4 2±1.3	4.7±1 3	4 3±0.7	4.5±1.4

POST post injury, TV tidal volume, CO cardiac output (MEAN ± S D)
*ANOVA $p<0.05$ vs. POST ** $p<0.05$ vs. VCV1 1

Conclusion. When PEEP is set above the LIP of the P-V curve, neither mode or I.E affects gas exchange or hemodynamics except V_D/V_T which improved with longer inspiratory times.

OF-97-120

THE RESPONSE TO POSITIVE END-EXPIRATORY PRESSURE (PEEP) DURING PARTIAL LIQUID VENTILATION (PLV) IS DOSE DEPENDENT.

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Partial liquid ventilation (PLV) with perflubron (PFB) has been proposed as an adjunct to the current therapies for the acute respiratory distress syndrome (ARDS). Since PFB has been also referred to as "liquid-PEEP", distributing to the most gravity dependent regions of the lung, less attention has been paid to the amount of applied PEEP. We recently reported, that the lower inflection point (LIP) of a pressure-volume loop shifts to the left with subsequently increasing doses of PFB [1]. We now hypothesized, that PEEP has an additive effect to different doses of PFB, when set above the LIP. **Methods:** Lung injury was induced by repeated lung lavage with warmed saline in 15 sheep until PaO_2/FiO_2 ratio fell below 150. To evaluate the impact of PEEP set above the LIP at different fill levels of PFB, three groups (n=5) with different doses (7.5 mL-15 mL-30 mL/kg/BW) of PFB were investigated. In random order a PEEP of 5 cm H_2O (BELOW) or PEEP above the LIP (ABOVE) was applied. Data for gas exchange, hemodynamics , and airway mechanics were analyzed using a 2-way ANOVA and HSD-post hoc. **Results:** No significant changes in hemodynamics were observed, data is reported in the table below ($C_{stat} = V_T / (P_{Plat} - PEEP_{Total})$):

	Dose	Preinjury	Injury	Below LIP	Above LIP
PaO_2	7.5	445 ± 95$^{\$}$	74 ± 14	68 ± 27	87 ± 66
	15	441 ± 102$^{\$}$	103 ± 35	152 ± 36	203 ± 68^{+}
[mm Hg]	30	425 ± 68$^{\$}$	98 ± 40	193 ± 57^{+}	298 ± 80$^{+\#\$*}$
$PaCO_2$	7.5	28 ± 4 1	31.2 ± 5 8	33 8 ± 5.8	34 4 ± 3 3
	15	34 ± 4 5	37.4 ± 3 3	37 8 ± 5 4	36 6 ± 5 0
[mm Hg]	30	34 ± 4 7	36.2 ± 3 1	41 2 ± 5 8	36 4 ± 3 6
C_{stat}	7.5	31 7 ± 8 0$^{\$}$	14 3 ± 3 2	14 4 ± 2 3	14 5 ± 3 0
[mL/	15	27 1 ± 5.1$^{\$}$	17 2 ± 3 4	20.3 ± 5 0^{+}	22 8 ± 5 8$^{\$+}$
cm H_2O]	30	25 0 ± 2 7$^{\$}$	15 6 ± 3 3	17 6 ± 3 5‡	22 8 ± 3 4$^{\$+*}$

Post hoc: within group: \$ $p < 0.05$ vs. Injury, * $p < 0.05$ vs Below LIP
across groups. + $p < 0.05$ vs. all stages, dose 7 5 mL/kg/BW; # $p < 0.05$ vs. Below LIP, dose 15 mL, ‡ $p < 0.05$ vs. Above LIP, dose 15 mL

Conclusion: The response to PEEP above the LIP is dose dependent and improves gas exchange and airway mechanics at moderate to high doses of PFB (≥ 15 mL/kg/ body weight)

[1] Fujino Y, Kirmse M, Hess D, Mang H, Kacmarek RM Relationship between fill-volume during partial liquid ventilation and the lower inflection point on a static pressure volume curve. Am. J. Resp. Crit Care 1997;155 A745

OF-97-121

NEGATIVE EXPIRATORY AIRWAY PRESSURE (NEAP) AND TRACHEAL GAS INSUFFLATION (TGI) IN COMBINATION AUGMENTS CO2 ELIMINATION MORE THAN TGI ALONE.

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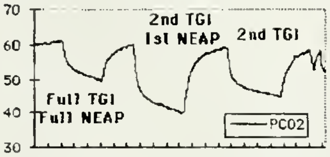
Background: A fresh gas flowing from a catheter positioned in the trachea has been shown to flush CO2 from anatomical and mechanical deadspace during the expiratory phase. The subsequent inspiratory phase then causes less CO2 rebreathing. As reported in clinical studies, TGI can cause ~15% reduction in PaCO2. NEAP was used in the 1950's to counter the adverse effects of positive pressure ventilation on the cardiovascular system. NEAP was abandoned due to its potential for airway closure. With currently available microprocessing and solenoid technology, it may be possible to phase NEAP to support the cardiovascular system, reduce mean lung volume or accelerate CO2 elimination without causing airway closure. We developed a microprocessor driven, double-solenoid system to deliver TGI, NEAP and TGI-NEAP combined to evaluate their respective effects on CO2 elimination during selected portions of expiration. **Methods:** In 5 paralyzed, sedated mongrel dogs we applied the TGI-NEAP system via 2 rigid catheters positioned one centimeter above the carina. Catheter flows were +9 L/min for TGI and -9 L/min for NEAP during phasing combinations of TGI and NEAP . We monitored arterial pressure, PAP, cardiac output, Pao, Ptr, Pes, inductance plethysmography (IP) and ABGs via an indwelling catheter (Paratrend 7). End expiratory lung volume was maintained constant by adjusting PEEP while guided by IP. **Results:** PaCO2 reduction was greatest in three phasing combinations: TGI-NEAP combined during exhalation (-12%), TGI in the second half of exhalation (-25%) and NEAP first half-TGI second half of exhalation (-46%). (Figure - PaCO2 vs. Time in 10 min increments) NEAP had a lesser effect on CO2 elimination than TGI. Overall, NEAP was effective in early exhalation while TGI was more effective in late exhalation. Lung volume excursion, as measured by IP, was observed to increase during early NEAP/late TGI. In this setting, no evidence of airway closure was observed. **Conclusions:** NEAP had a role in CO2 elimination that was phase specific and less than TGI. We speculate that a combination of early NEAP-late TGI is additive due to their different mechanisms of action and that minute ventilation is increased by this combination. Supported by SCOR HL50512.



OF-97-139

EFFECT OF INTERACTIONS BETWEEN TRACHEAL GAS INSUFFLATION (TGI), MECHANICAL VENTILATION AND TOTAL-PEEP ON $PaCO_2$ IN ARDS

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TGI flushes CO_2 from the anatomical airways and decreases dead space ventilation. However, TGI in conjunction with mechanical ventilation (MV) results in the development of auto-PEEP leading to an increase in total-PEEP ($PEEP_{vent}$ + auto-PEEP). As total-PEEP increases, CO_2 elimination is reduced as a result of the increase in alveolar deadspace. The final effect on $PaCO_2$ depends on the interactions between TGI, MV, and total-PEEP. Thus, we sought to measure the effects of TGI on total-PEEP and CO_2 elimination during volume and pressure control ventilation in patients with ARDS METHODS: TGI catheter was placed 2 cm beyond the distal tip of the endotracheal tube with flow rates of 0 and 10 L/min. Peak airway pressure (Peak Paw) was measured at the proximal end of the endotracheal tube. Minute volume (V_E) was derived using respiratory inductive plethysmography (RIP) Group 1A (n=4) volume control ventilation with $PEEP_{vent}$ constant. Group 1B (n=4) pressure control ventilation (PCV) with $PEEP_{vent}$ constant. Group 2 (n=5) PCV with $PEEP_{vent}$ decreased to maintain total-PEEP constant. Data were collected at the end of each 30 minute experimental condition.

	Group 1A			Group 1B			Group 2		
TGI (L/min)	0	10	0	0	10	0	0	10	0
Peak Paw (cm H_2O)	40.1	46.1	41.2	42.3	43.0	42.1	39.1	38.5	40.9
V_E (L)	9 1	9.3	9.4	10 1	8.6	10.0	11.4	11.3	11.9
Total PEEP (cm H_2O)	14.9	20.9	14 9	12 5	16.8	12.5	11 3	11.3	11 4
$PaCO_2$ (mm Hg)	46.3	44 8	47.8	60 3	58.3	60.8	65.4	57.6*	67.2

*$P< 0.05$ when compared to zero flow

CONCLUSION: 1. TGI-induced increase in auto-PEEP inhibits the ability to decrease $PaCO_2$ due to its effect on total-PEEP and V_E 2. Decreasing $PEEP_{vent}$ during TGI will keep total-PEEP constant, resulting in a lower $PaCO_2$ for a constant V_E.

OF-97-148

CASE STUDY OF VENTILATOR GRAPHICS AS AN ADJUNCT TO LIQUID VENTILATION IN PREMATURES

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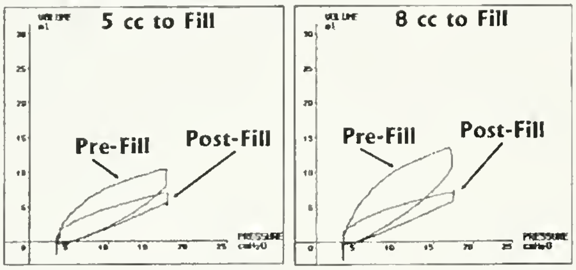
Background: Prematures with severe RDS have been studied on liquid ventilation as a national study. When liquid ventilation has been used, frequent refilling is required (up to Q hour) Filling has been based on chest x-rays, endotracheal tube meniscus, and intermittent pulmonary function testing **Hypothesis:** We wanted to determine if real-time ventilator graphics of pulmonary function change before and after refilling the liquid for ventilation of the lungs of a premature **Methods:** In this case study, the premie was ventilated with the Bear Cub 750 including the real-time graphics package We monitored the premie before refilling and after refilling. Pressure/Volume Loops (graphical representation of PFT values) were printed out as shown below **Results:** The figures represent Pressure/Volume Loops of a premie on liquid ventilation just before refilling the lungs (Pre-Fill) and then just after refilling the lungs (Post-Fill). For these two separate fills, 5 cc was used in the first and 8 cc was used in the second



Conclusions: In this case, change can be appreciated in the Pressure/Volume Loops with refilling during liquid ventilation Changes include both change in the area of the curve and slope of the curve. We have not yet done quantitative measures, but graphics alone will help bedside clinicians determine when refilling is necessary. The application of graphics may also play an important role in surfactant or bronchedilator delivery, endotracheal tube placement, and endotracheal tube leak management.

OF-97-171

INITIAL EXPERIENCE WITH A RAPID-RESPONSE ECMO SERVICE

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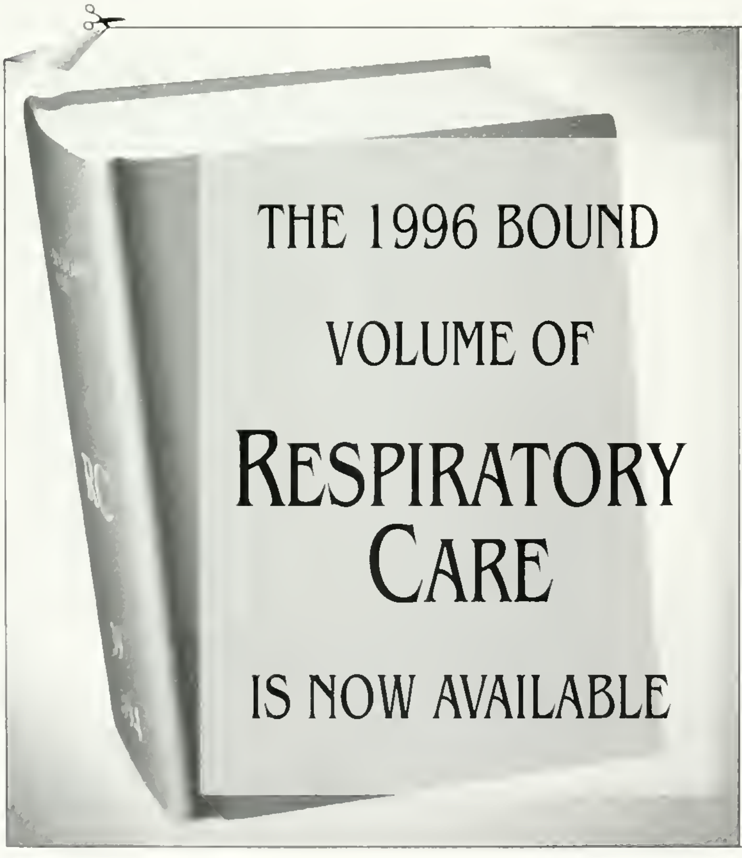
BACKGROUND: Extracorporeal membrane oxygenation (ECMO) has been available in our institution since 1984. Beginning 2/96, we modified our ECMO circuit in order to provide a rapid-response ECMO service capable of supporting patients during cardiopulmonary arrest. We report our initial experience with this service from 2/96-5/97. METHOD: A pre-assembled ECMO circuit capable of supporting patients up to 20 kg, is maintained in our PICU. The circuit includes a silicone membrane and roller pump and is CO_2/vacuum primed. Upon activation of the rapid-response ECMO service, the circuit is prepared with a crystalloid/albumin prime and is ready within 20 minutes. If time permits, the circuit is further primed with blood products, otherwise initiation of ECMO proceeds with a crystalloid prime. ECMO support is established by a veno-arterial route either transthoracically or via neck vessels. Respiratory therapists, trained in the establishment of ECMO support, provide 24 hour coverage for this rapid-response ECMO service. A new ECMO circuit is assembled every 7 days if the system is unused. RESULTS: The rapid-response ECMO service was activated 24 times, in 6 different hospital locations, and with a response time of $\leq$ 20 minutes. Nine patients recovered without needing ECMO. Fifteen patients required ECMO, 8 of which required cardiac compression throughout the cannulation procedure. Diagnoses included cardiac failure, congenital diaphragmatic hernia and sepsis. The median age was 6 weeks (1 day-4 years) and the median weight was 4.0 kg (2.4-15 kg). The overall survival rate was 67% (10/15). Additionally, emergent ECMO was requested for 6 patients weighing > 20 kg. DISCUSSION: Historically in our institution, the decision to initiate ECMO has been elective, and ECMO has been staffed by respiratory therapist with an on-call system. We have found the implementation of a rapid-response ECMO service feasible. The favorable survival rate may be attributed to the availability of the rapid-response ECMO service. Future considerations will center on investigating different technologies to expand our rapid response ECMO service to include patients > 20kg. Additionally, infection control, cost-effectiveness and long-term patient outcome need to be evaluated.

OF-97-182



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THE FINANCIAL IMPACT OF A SMOKE FREE POLICY IN RESTAURANTS

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Introduction: In our region, approximately 80% of the population are nonsmokers. The general population in our area, and we expect nationwide, has a good understanding of the hazards of smoking and second hand smoke. In spite of an understanding of these hazards, many restaurants are reluctant to change their smoking policy based on a perception of the potential lost revenue from implementing a smoke free environment.

Hypothesis: There would be no difference in revenue after implementation of a smoke-free environment in restaurants or bars.

Methods: Respiratory Care students from our 1995 and 1996 classes surveyed every restaurant or bar which served food, in our community of approximately 80,000 for two years in sequence. Consent was implied by those restaurant managers who completed a short branching phone questionnaire. This questionnaire dealt with demographic information and questions regarding the restaurants smoking policy.

Results: A total of 167 (96%) out of 174 possible restaurants and bars which served food participated in the 1996 study. The prevalence of smoke free restaurants increased 4% in one year between the 1995 (35% smoke free) and 1996 (39% smoke free) surveys.

	YES	NO
1. Do you allow smoking? [If yes go to questions 2, 3, 4, if No go to questions 5, 6, 7]	102 (61%)	65 (39%)
2. If allow smoking do you have separate sections?	93 (91%)	9 (09%)
3. If you have separate sections, do you have barriers? Those responding "Yes", generally considered a half wall, ventilated walls, or plants as a smoking barrier.	44 (47%)	49 (53%)
4. Have you considered a smoke free policy? The most frequently cited reason for not implmenting a smoke free policy, was the possibility of reduced revenue by not offering a smoking option to patrons.	41 (44%)	52 (56%)
5. If you have implemented a no smoking policy, how many months have you been smoke free? [23 +/- 13 months]		
6. Would you consider a return to a smoking policy?	8 (12%)	57 (88%)
7. How has a smoke free policy impacted business? 100% of respondents (n=56) experienced no measureable difference in revenue, several citing an unanticipated increase in revenue, mostly from traffic from parents with small children.		

Conclusions: We found smoke free restaurants are becoming more prevalent. Responses to questions #3 indicate inadequate separation of the sections by any physical or environmental barrier, since smoke is an airborne aerosol, they are providing a nonsmoking section in name only. The most frequently cited reason for not implemeting a smoke free policy was concern regarding the impact on revenue. Implementation of a smoke free policy does not appear to negatively impact revenue and in some cases an increase in revenue. We conclude more restaurants would favorably consider a change to a smoke free policy when they see revenue is not negatively impacted. More research is indicated to further define the trend in restaurant smoking policy and it's effect on revenue.

OF-97-009

FOUR YEAR PROSPECTIVE STUDY OF LUNG FUNCTION IN COLLISION REPAIR WORKERS

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Purpose: Di-isocyanates (DI), which can cause occupational lung disease, are found in many products used in the collision repair industry. Collision repair workers (CRW) are exposed to varying levels of DI dependent on equipment in use, shop ventilation, and volume of repairs in progress. We hypothesized a CRW who smoked (Smk) would have a worse PFT than the CRW who did not smoke (NonSmk), or from the CRW who had smoked previously but had now quit (QuitSmk). We previously found no difference in PFT in Smk vs NonSmk vs the general population. We report the results of a 4 year study of PFT in CRW's.

Methods: We tested 38 CRW volunteers twice with a four year interval between tests. Consent was implied by participation in testing. We used a PFT machine calibrated to meet ATS guidelines. Once a proper FV loop was obtained, the test with the highest value for FVC and FEV1, was reported for analysis

Results: Data was analyzed using ANOVA utilizing Statistix software. Significance was to occur with a $p < .05$.

	NonSmk n=21	Quit Smk n=11	Smk n=6	p
Age (yrs)	41.6± 8.7	48.4±10	42.2±7.8	.13
Ht (ins)	70.7± 2.8	70.4±2.6	69.2±3.2	.49
Wt (lbs)	199±29.0	191±29.5	188±27.0	.65
Pkyrs	——	16.2±16.8	28.7±17.6	—
CRWyrs	18.8±10.5	20±7.9	23±9.9	.59
FVC(l) Initial	5.05±.90	4.85±1.25	4.92±1.18	.87
FVC 4yr	5.15±.84	4.89±1.26	4.89±1.33	.76
FEV1(l) Initial	4.06±.69	3.84±.97	4.01±1.14	.78
FEV1 4yr	4.19±.81	3.89±.91	4.09±1.24	.68
FEV% Initial	.80±.05	.78±.05	.83±.05	.26
FEV% 4yr	.81±.08	.80±.06	.83±.05	.70

Conclusions: The lung related effects of di-isocynate can range from hypersensitivity pneumonitis to chronic asthma. Others have demonstrated an increased rate of FVC loss in CRW who have smoked when compared to nonsmoking CRW.[1] The subjects we studied are from a rural state where the only significant factors affecting lung function would be smoking history and occupation. We found no significant difference in lung function of the two populations. However, continued study of the CRW is still indicated due to the exposure risk of this environment.

1. Tornling, et al, Am-J-Ind-Med, 1990:17(3):299-310

OF-97-012

HIGH FREQUENCY VENTILATION IN A CASE OF SEVERE ATHROGRYPOSIS MULTIPLEX CONGENITA.

Steve Sittig, RRT, Pediatric-Perinatal Specialist, Scott LeBard, M.D., Mayo Eugenio Litta Children's Hospital, Rochester , Minnesota

Introduction: In this case study we describe how we utilized the Sensormedics 3100 high frequency ventilator in the postoperative management of a 36-kg, 16-year-old male with severe athrogryposis.

Case Summary: The patient was admitted for anterior/posterior fusion for progressive scoliosis. A chest x-ray prior to surgery showed a 100° curvature of the spine. Pulmonary function tests revealed a total lung capacity of 46% and an FEV_1 of 32%. He initially underwent anterior exposure of the thoracolumbar spine for multiple diskectomies (10). He was maintained postop on conventional ventilation without complications. On hospital day 8, he underwent posterior fusion with instrumentation requiring 2 right-sided chest tubes and 1 on the left. Postop, he was initially returned to his preoperative ventilation settings of SIMV 14, V_t 450 mL, PEEP 7 cm H_2O, but required 80% FiO_2. Peak airway pressures were noted to be over 50 cm H_2O; therefore, the ventilator was changed to pressure control assist control rate 14, peak inspiratory pressure (PIP) 38, inspiratory time (IT) 1.5 sec, PEEP 8 cm H_2O, mean airway pressure (MAP) 22, and FiO_2 of 80%. Delivered V_T was 450 mL. Five hours postop, a chest x-ray showed a right-sided pneumothorax. The anterior right chest tube was repositioned with resolution of the pneumothorax. As compliance increased, the PIP was weaned to 32 cm H_2O with a delivered V_T of 480 mL. PIP was continually monitored and adjusted to maintain delivered V_T of around 440 mL. Twelve hours postop, the delivered V_T and SaO_2 dropped significantly. A repeat chest x-ray showed a large left pneumothorax requiring a second left-sided chest tube. At this point, he was placed on high frequency ventilation via Sensormedics 3100. Initial settings were FiO_2 1.0, amplitude delta p of 80 cm H_2O, MAP 30 cm H_2O , frequency 7 Hz, and IT 40%. The first arterial blood gas showed a pH 7.28, PCO_2 85, PaO_2 63, with a correlating $TcPCO_2$ of 87. The frequency was decreased to 5 Hz and the IT to 50% to increase minute ventilation. The $TcPCO_2$ decreased from 82 to 67. Initial chest x-ray on HFO showed total resolution of the bilateral pneumothoracies with moderate right lower lobe (RLL) consolidation. A bronchoscopy was done on day 3 of HFO ventilation; no mucus plugs were noted. He was then placed with the left side down to aid right lung reexpansion with successful results. For 12 days, he was maintained on HFO, adjusting settings to 3 Hz, delta p 80, MAP 24 cm H_2O, 50% IT, and 65% FiO_2. In order to remove sedation/paralytic agents and allow spontaneus respiration, he was placed on pressure control AC 48, PIP 28 cm H_2O, PEEP 7cm H_2O, IT of 0.5 sec and 70% FiO_2. He tolerated the transition with acceptable ABGs. He underwent a tracheostomy on postop day 21 to facilitate weaning. His pulmonary mechanics slowly improved, and on postop day 33, he was changed to volume ventilation. Slow, conventional weaning progressed as he improved. On day 89, he was transferred to the general pediatric floor on a 35% trach collar.

Discussion: In this case study, we report the successful application of the Sensormedics 3100 in a difficult-to-manage ventilator patient with a restrictive lung component. While the Sensormedics was initially limited to patients under 35 kg, documented cases of successful management over this weight are being reported. Due to the unique pathology, recurrent airleak, and patient's size, we felt this case to be worth reporting.

OF-97-022

A SURVEY OF ASTHMA CARE AND EXPERIENCE IN DAYCARE AND PRESCHOOL CENTERS

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Introduction: There have been many programs developed and implemented to either improve or introduce routine asthma education and care into public schools. Recent data reveal increases in the prevalence of asthma in children less than five years old. Despite this data, there are no programs currently available to address asthma education and care in daycare or preschool facilities. In working with parents of asthmatic children, we have been informed of situations where parents have either lost or quit their jobs to provide daily care for an asthmatic child, because either the daycare facility would not provide treatments or the parents did not feel comfortable with the facility's experience in asthma care. **Objective:** Develop and administer a survey to daycare facilities to determine the need for an asthma education program. **Methods:** A survey instrument was developed and mailed in January 1997 to 700 Northeast Ohio license daycare and/or preschool facilities **Results:** 41% of the surveys were returned within a 6 week period. Of the respondents, 97% of the facilities reported accepting children with asthma. Twenty-one percent of the centers have had a child experience an asthma attack at their facility. Below are some additional data from the survey (listed as % respondents rounded to nearest whole number).

	Yes	No	Unsure / No Answer
Centers providing routine treatments	47	48	5
Centers providing treatment for symptoms	43	46	12
Centers willing to provide treatments with proper training	73	11	16
Centers aware of asthma signs and symptoms	61	11	28
Centers aware of potential asthma triggers	57	15	28
Experience Level	None	Some	Very
Centers familiar with asthma medications and use	34	58	9
Centers familiar with delivery devices and use	23	67	10

Setting	%	Enrollees	%	Asthmatics	%	Stay (hrs.)	%
Rural	11	0-15	3	0	6	0-4	32
Suburban	70	16-30	8	1-5	71	4-6	11
Urban	19	31-50	24	6-15	12	6-10	57
		> 50	65	>15	2		
				unknown	9		

Conclusion: Daycare facilities are confronted with an increasing number of children with asthma in their facilities. Less than 50% of the facilities responding provide treatment to asthmatic children. Despite low percentages in treatments administered, experience or asthma education, 97% of these facilities accept children with asthma. From this survey's data, there appears to be a need for an asthma program directed towards daycare/preschool programs. A program is currently being developed.

OF-97-053

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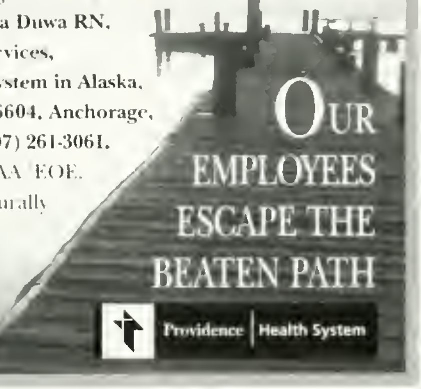
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A SCORING SYSTEM FOR PEDIATRIC ASTHMA IMPROVES APPROPRIATE ICU ADMISSION RATE

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At our facility, appropriate pediatric intensive care unit (PICU) admissions for status asthmaticus are patients that require aerosols more frequently than Q2H. Patients treated less frequently are admitted to general divisions. All patients, regardless of setting, are placed on an inpatient care path when treatment reaches Q2H. Admission setting is based on the subjective impression of the emergency department (ED) attending physician. A retrospective analysis of 280 consecutive admissions from the ED indicated that 226 division admissions (100%) were appropriately placed. Of the 54 PICU admissions, 29 were appropriate (54%) and 25 were inappropriate (46%). Our data show inappropriately admits to the PICU from the ED have the same average length of stay (LOS) as patients admitted to our divisions (1.9 days vs. 1.8 days; p=0.9999). The average cost difference is $1,858 / patient. **Objective:** To determine if an assessment-based ED scoring system can make more appropriate PICU admissions for children in status asthmaticus than the current subjective admission method. **Participants:** All children, ages 1-16, consecutively admitted to our hospital from the ED over 5 months. **Methodology:** All patients were treated using an ED asthma care path, consisting of standard assessment criteria (wheeze, air exchange, accessory muscle usage, pulse oximetry and respiratory rate) and set treatment intervals (Q20 minutes). Patients that failed to respond to treatment were admitted after receiving 6 aerosol treatments or continuous aerosols for one hour. Admit destination was determined by the ED attending physician. For this study, a numerical scoring system was invented based on weighted assessment criteria. Scores were based on each patient's first and last ED assessments. Receiver operating-characteristic curves were plotted to determine the threshold value that best discriminated appropriate division and PICU admissions. A Fisher Exact test was used to compare the proportion of appropriate admissions as they actually occurred with what would have happened if admissions were based on the score. **Results:** A mean score of ≥10.5 was found to best discriminate appropriate PICU admission. Supplemental criteria were an increasing score (indicating worsening despite treatment) or continuous aerosol therapy. A score of <10.5 indicated appropriate admission to the divisions. The objective scoring system would have reduced inappropriate PICU admissions from 46% to 20% compared to the current subjective physician impression (see below):

	Objective	Subjective	p-value
PICU Admits			0.0136
Appropriate	28	29	
Inappropriate	7	25	
Floor Admits			>0.9999
Appropriate	244	226	
Inappropriate	1	0	

Conclusion: The proposed objective scoring system is better at assigning appropriate PICU admissions than subjective admission decisions. Based on the average difference in hospital cost, the scoring system would have saved $33,444 (18 inappropriate admits). With an average of 140 PICU asthma admissions (46% of admits inappropriate) from the ED, the scoring system would save approximately $67,631 / year. A prospective test of the system is underway.

OF-97-064

A CASE REPORT: ACUTE ACQUIRED BENZOCAINE -INDUCED METHEMOGLOBINEMIA

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Introduction: Topical application of Hurricane Spray containing 20% Benzocaine resulted in acute acquired methemoglobinemia. Case Summary: A 65 year old female with pneumonia presented to the Medical Intensive Care Unit in respiratory failure requiring intubation. The patient was prepared for intubation using two 2 second sprays of benzocaine to the oropharynx. The patient experienced a lot of coughing post intubation and a third 2 second spray of benzocaine was given to the oropharynx. Pre and post intubation sedation was given to facilitate comfort, totaling 4 mg versed, 5 mg valium, and 2 mg morphine. Mechanical ventilation was initiated resulting in a SpO2 of 96% with an FiO2 of .80. Thirty minutes after intubation the patient's condition deteriorated with blood pressure dropping from 137/59 mmHg to 77/35mmHg and SpO2 dropping to 85% with an increased FiO2 of 1.0. The patient looked much more cyanotic than the SpO2 indicated. CXR confirmed proper tube placement and no pneumothorax. 1.5 L of normal saline in addition to 5 micrograms/kg/min of Dopamine and 3 micrograms/kg min of Dobutamine were given to maintain blood presssure. Arterial blood gases were pH 7.44/ PaCO2 30 and PaO2 260 with a mSaO2 of 68% and MetHgb of 30.7%. The normal range for methemoglobin is 0.1-2%. The arterial blood was a distinctive purplish black unlike the browninsh hue/chocolate brown appearance as reported in the literature. Methylene blue was given at 1mg/kg(75mg) over a 15 minute period. ABG's were repeated 15 minutes after infusion of methylene blue and were: pH 7.39 PaCO2 32/PaO2 209 with a MetHgb of 13.4%. Another dose of methylene blue was given over 15 minutes with ABG's repeated in 30 minutes. The metHgb had lowered to 8.4%. ABG's continued to show further lowering of the Methemoglobin. Discussion: There are several other drugs or groups of chemicals that can cause methemoglobinemia. These include sulphonamides, nitrates, nitrites, aniline dyes, antimalarials, anesthetic agents (such as prilocaine, lidocaine, procaine), Vitamin K analogues, Resorcin, Phenacetin, Chlorate, Dapsone, acetaminophen, and Naphthalene. The only drug that this case patient received prior to admission to the MICU service was lasix. Review of the literature reports 54 other cases of benzocaine induced methemoglobinemia that have caused serious oxygentation and cardiovascular compromise. Without prior knowledge of benzocaine-induced methemoglobinemia, practitioners can be caught off guard about the compromising events that can occur from a seemingly benign procedure.

OF-97-060

HYPOTONIC TRACHEO-BRONCHIAL DYSKINESIA A NEW LOOK AT AN UNCOMMON RESPIRATORY DISORDER

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Hypotonic tracheo-bronchial dyskinesia (HTBD) is a rather uncommon (underestimated ?) disorder only few cases have been reported in recent literature. We evaluated four cases of HTBD through functional (flow-volume curve), endoscopic (FBS) and computed tomographic (CT) examination. Symptoms of HTBD are non specific, resulting from impaired ventilatory mechanism and ineffective cough: variable degree of breathlessness, dyspnoea, expiratory wheeze, persistent or abnormal cough, worsening of a baseline disease. By a functional point of view, a flow-volume loop with signs of variable intrathoracic obstruction may suggest the diagnostic hypothesis of HTBD. The expiratory loop is abnormal on the highest point of peak flow: a flattening of PEF occurs while the rest of the loop may be almost normal. Finally, some functional aspects deserve to be pointed out: 1) no modification occurs in the flow-volume loop after inhalation of β_2-agonists; 2) normal FEV_1 and FVC may be observed even if the maximal expiratory loop is reduced. HRCT and/or multiplanar electronic reconstruction confirmed our bronchoscopic findings and proved to be useful for the diagnosis of HTBD.

Key Words: hypotonic tracheobronchial dyskinesia-intrathoracic obstruction-high resolution computed tomography

HTBD, hypotonic tracheobronchial dyskinesia; FBS, fiberoptic bronchoscopy; HRCT, high resolution computed tomography; PEF, peak expiratory flow; FEV_1, forced expiratory volume in 1 sec; FVC, forced vital capacity

OF-97-088

A Novel Approach to Ventilating a Neonate During Hyperbaric Oxygen Treatment: A Case Report **R Scott RCP RRT, L Langga RCP RRT, D Sample RCP RRT, P Tran MD, D Bland MB, T Lo MD, Loma Linda University Medical Center, Loma Linda, California.** **Introduction:** There are few reported cases of neonates receiving Hyperbaric Oxygen (HBO_2) treatment, and no known reports of any being mechanically ventilated during this process We present a case of a mechanically ventilated infant needing adjunctive HBO_2 after failing conventional therapy for severe necrotizing fasciitis (NF) and abdominal wall infection **Case Summary:** A 12-day old caucasian female was referred for adjunctive HBO_2 treatment. The patient developed NF of the anterior abdominal wall refractory to local wound care, intravenous (IV) antibiotics, and surgical intervention. Abdominal complications led to deterioration of the respiratory status, and the patient was placed on mechanical ventilation The patient was referred for HBO_2 to treat the NF The standard HBO_2 ventilator system was deemed insufficient for the neonate's needs The decision was made to have a respiratory care practitioner (RCP) manually ventilate the infant during compressions A Laerdal pediatric resuscitation bag and valve system was selected for ventilating the infant The RCP manually ventilated the infant during the entire 60 minute regimen Ventilation, vital signs, and temperature were monitored during each compression Our patient underwent 22 HBO_2 treatments at two atmospheres absolute There was no complication from HBO_2 The patient received a 21 day course of IV antibiotics and subsequent successful abdominal wall closure **Discussion:** There has been considerable experience in the use of mechanical ventilation in a monoplace HBO_2 chamber with larger children and adults, but no known reported cases involving neonates In our facility, the Sechrist 500A ventilator is used with the Sechrist monoplace HBO_2 chamber The 500A is a time cycled, pneumatically controlled volume limited ventilator Tidal volume (VT) is set by the inspiratory to expiratory ratio and flow rate Tidal volume is affected by changes in chamber pressure, lung compliance, and inlet pressure The following limitations make the 500A difficult to use with neonates compression and decompression significantly alter VT; the inspiratory time is limited to > 1 sec; the accuracy of the turbine style spirometer is insufficient These conditions challenged us to develop an alternative method to ventilate our patient Thombs et al suggested manual ventilation as a method to effectively ventilate an infant undergoing HBO_2 treatment We chose to place a RCP in the chamber to manually ventilate the infant The RCPs provided effective ventilation, maintain airway patency, and assessed the patient's clinical status throughout each compression Monitoring tools were limited Maintaining a neutral thermal environment was a major concern Cotton blankets were used to conserve body heat and reduce convective and evaporative heat loss The infant's temperature was taken regularly using glass, non-mercury thermometers. Selection of the diving RCP was determined on a voluntary basis The RCPs were in good health and free of middle ear problems, colds, or sinus infections **Conclusion:** Ventilation of an infant in the monoplace HBO_2 chamber is a challenge Based on our experience, manual ventilation of a neonate is a viable alternative in safely ventilating an infant receiving HBO_2 in a monoplace chamber Our case highlights the need for a mechanical ventilator capable of providing ventilatory support of neonates undergoing HBO_2 treatment

OF-97-096

ENDOBRONCHIAL AIRWAY MANAGEMENT USING A COMBINATION CAPNOGRAPHY AND RESPIRATORY PROFILE MONITOR-Chris Cella, RRT, John Dobrozsi, RRT, Josh Benditt, MD University of Washington Medical Center, Seattle, WA Introduction- Independent lung ventilation (ILV), and dual lumen endotracheal tubes (DLETT) are used in a variety of clinical settings. Simple activities such as head movement or routine turning may affect DLETT position adversely. The misplacement of the DLETT can go undetected by RCP's . The use of respiratory profile monitors that include capnography and respiratory mechanics can assist to detection of tube placement. Improper DLETT placement and cuff inflation or deflation can quickly lead to potential life threatening situations. We report the experience in two such patients as summarized below.

Case 1- A 67 yo male with severe emphysema, underwent Lung Volume Reduction Surgery (LVRS) One month following surgery, he was admitted to the ICU for pneumonia and was electively intubated in the ICU with a 39 Fr DLETT. Verification of DLETT placement was evaluated by a colormeteric device which was attached to a Carlens Y adapter, by auscultation and chest radiograph. Four hours after ventilation was initiated, the patient's condition deteriorated with decreasing SPO2's and hypotension. A pair of CO_2SMO *Plus* Respiratory Profile Monitors (Novametrix Medical Inc., Wallingford CT) were placed on the tracheal and bronchial lumens of each tube. With both cuffs inflated, the ETCO2 was 0 and volume and flow waveforms were flat from the bronchial lumen. ETCO2 and waveforms were within normal limits on the tracheal lumen. When the bronchial lumen was deflated, volume, flow, and ETCO2 waveforms returned. A bronchoscopy revealed a moderate amount of edema partially obstructing the left bronchial lumen. The bronchial cuff was reinflated, and once again ETCO2, flow and volume waveforms decreased to zero baseline. The patient was transferred to the OR so that his airway could be stabilized.

Case 2- A 46 yo male with a history of a right lung transplant, and left LVRS was admitted for acute respiratory distress secondary to pneumonia. He became increasingly tachypneic, and hypertensive and was electively intubated under bronchoscopic observation with a 39 Fr DLETT. During intubation the bronchial cuff was noted to be "high" and barely occluding the L mainstem bronchus even though the tube had been advanced as far as possible without sacrificing secure stabilization at the patients lip. ILV was initiated and respiratory mechanics/ETCO2 were monitored using two CO_2SMO *Plus* monitors connected to each lumen respectively. The ETCO2 value was noted to be 0 (zero) and the negative deflection of the flow waveform was absent from the bronchial tube. The Servo ventilator low exhaled volume alarm activated, but it was unclear as to the etiology of the violation. Exhaled volume from the tracheal lumen was noted to be greater than the delivered volume and the ETCO2 remained within normal limits. The bronchial cuff was determined to be ineffective at occluding the L mainstem. Ventilation was continued using a single ventilator wyed to the endobronchial tube and the bronchial cuff deflated. Discussion- In these two cases, independent monitoring of ETCO2, and flow waveforms from both lumens of DLETT resulted in the diagnosis of potential life threatening conditions. The authors feel that monitoring of these parameters to be of great value, and that continued study of their use is necessary.

OF-97-101

PRESSURE CONTROL VENTILATION TO STABILIZE MINUTE VENTILATION WITH AN AIRWAY LEAK: A CASE STUDY

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INTRODUCTION: Leaks associated with artificial airways can complicate mechanical ventilation by altering minute ventilation (VE), contributing to instability of gas exchange. Variable leaks are problematic when they can not be corrected by the reinsertion of a larger artificial airway or head/body repositioning. Data from a model study (Respir Care 1996;41(8):728-735) suggest that pressure controlled ventilation (PCV) will maintain a more stable minute ventilation than flow controlled ventilation (FCV). No patient data have been published to support this hypothesis. **CASE SUMMARY:** A 68 year old white male motor vehicle accident victim with closed head and chest trauma was transported to our Level 1 trauma center. The patient was immobilized on a back-board with C-Collar, and required oxygen at 15 L/m by non-rebreathing mask. The patient was alert and oriented, without evidence of respiratory distress. Physical exam of the chest revealed abrasions along with subcutaneous emphysema extending to the neck and face. Breath sounds were diminished bilaterally and bilateral chest tubes were placed. Shortly thereafter he demonstrated difficulty breathing and profound hypotension. EKG showed an accelerated junctional rhythm with ST elevation consistent with a left inferior wall MI. Several attempts at elective oral intubation were unsuccessful and a cricothyroidotomy was performed, using a size 6.0 cuffed Shiley tracheostomy tube.The patient remained hemodynamically unstable with a metabolic acidosis. Mechanical ventilation was initiated and a high VE , (17 L/m) targeted to prevent worsening acidosis. The Nellcor Puritan Bennett 7200 ae ventilator provided flow controlled SIMV (descending ramp flow waveform) with rate of 18/min, Vt = 0.9 L, PEEP = 10 cm H2O, FIO2 = 0.85, PS = 8 cm H20. A variable airway leak contributed to unstable exhaled VE ranging from 14.0 - 17.0 L/m and peak inspiratory pressures (PIP) of 31 - 42 cm H2O. Within 12 hours, a continuous airway leak was noted resulting in a reduction in exhaled VE to 14 L/m. The leak was estimated to be 18%. Reintubation was not an option as there was significant airway trauma and edema visualized by direct laryngoscopy. C-spine immobilization and subcutaneous emphysema made initiatives for leak compensation by head and/or body repositioning difficult. The ventilator was switched to PCV with pressure limit of 33 cm H2O above the set PEEP of 10 cm H2O. This resulted in a rapid rise of VE to 28.9 L/min. Applied pressure was rapidly weaned to 28 cm H2O, achieving the target VE of 17 L/m. Reduction of pressure eliminated an audible leak. The patient eventually succumbed to cardiac compromise due to cardiac contusion. **DISCUSSION:** The literature defines massive airway leaks as > 10% of the tidal volume (Bernstein, Crit Care Med 1995;23(10)1739-1744). It is commonly believed that FCV with a descending ramp flow waveform simulates PCV, limiting airway pressure and improving gas exchange (Intens Care Med 1985;11:68-75). In this patient, PCV delivered more of the target VE than did FCV with a comparable PIP. This may be due to the fact that acutal (rather than simulated) pressure control can generate unlimited flow to "feed" a leak and maintain inflating pressure longer to yield higher tidal volumes. This clinical observation supports and broadens the scope of the theoretical data cited above. PCV may be preferable to FCV in patients with unstable ventilation associated with airway leaks.

OF-97-113

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COMPARISON OF A PORTABLE POINT-OF-CARE BLOOD GAS AND ELECTROLYTE ANALYZER (SENDX-100™) WITH CONVENTIONAL ANALYSIS IN BOTH LABORATORY AND CLINICAL SETTINGS

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Introduction: Point-of-care (POC) testing is a rapidly developing aspect of clinical medicine. The purpose of this study was to determine the accuracy and reliability of a specific POC blood gas/electrolyte analyzer (SenDx Medical Inc, Carlsbad, CA) compared with conventional laboratory (Lab)-based analysis when the POC device is used by both laboratory technicians and clinical personnel. **Methods:** Approval of the Institutional Review Board was obtained The study compared results obtained from conventional blood gas/electrolyte analyzers and those obtained from POC devices Clinically indicated blood specimens were analyzed via a split sample technique The study was carried out with two POC devices placed in the laboratory and two placed in the clinical environment After 100 data points, the position (i e , laboratory vs. clinical) of the devices was switched In the laboratory, the specimens were split by laboratory personnel between conventional blood gas/electrolyte analyzers and the POC devices In the clinical environment, clinically indicated blood samples were split at the point-of-care One portion of the sample was analyzed at the bedside by respiratory therapists using the POC device and the remaining portion of the sample was sent immediately to the laboratory for conventional analysis. The results of both analysis techniques in both environments (laboratory and clinical) were compared via the method of Bland and Altman. **Results:** A total of 200 data points (50 for each POC device) were obtained. Data obtained from each analyzer were pooled and are presented in the table. There were no P_aO_2 values >200 obtained with the POC device in the clinical setting. All parameters tested, in both the laboratory and clinical settings, demonstrated results which are consistent with guidelines for laboratory performance. **Conclusions:** The SenDx-100 POC blood gas/electrolyte analyzer performed with precision and accuracy equivalent to conventional laboratory methods for all parameters in the hands of both laboratory and clinical personnel in a critical care setting

			pH	$PaCO_2$	PaO_2 <100	PaO_2 100-200	PaO_2 >200	Na+	K+	Ca++	Hct
1	Lab	Bias	0.0	-0.1	-1.5	2.0	-1%	0.3	0.03	0.05	0.3
		Precision	±0.01	±1.6	±2.6	±6.6	±1%	±1.7	±0.08	±0.03	±2.8
	ICU	Bias	0.0	-0.2	0.4	-0.3		1.5	0.04	0.05	0.5
		Precision	±0.02	±0.7	±2.2	±6.9		±1.9	±0.08	±0.04	±6.6
2	Lab	Bias	0.0	0.4	-2.8	-3.6	-4%	-0.5	0.02	0.06	0.7
		Precision	±0.01	±1.6	±3.6	±7.8	±1%	±2.2	±0.08	±0.03	±1.9
	ICU	Bias	0.01	-0.8	0.3	-1.9		0.9	0.0	0.06	0.8
		Precision	±0.01	±0.7	±3.1	±3.3		±3.1	±0.1	±0.07	±2.6
3	Lab	Bias	0.01	-0.3	-3.1	-4.3	-2%	0.13	0.01	0.06	0.1
		Precision	±0.02	±2.3	±2.3	±4.8	±2%	±1.6	±0.09	±0.03	±2.4
	ICU	Bias	0.01	-0.5	-1.2	-1.4		0.9	0.05	0.0	-0.6
		Precision	±0.01	±1.1	±2.8	±3.7		±2.2	±0.08	±0.06	±2.7
4	Lab	Bias	0.01	-0.8	-4.3	-0.8	-8%	-0.7	0.02	0.05	0.6
		Precision	±0.01	±1.3	±2.8	±4.9	±3%	±2	±0.1	±0.03	±2.4
	ICU	Bias	0.01	-0.8	-4.0	-9.2		1.0	0.06	0.03	-0.8
		Precision	±0.01	±1.5	±5.4	±2.9		±1.8	±0.13	±0.04	±2.1
Guidelines for Variance			±0.04	±4	±4	±8	±10%	±4	±0.4	±0.06	±6%

OF-97-098

LABORATORY EVALUATION OF CLOSED SUCTION CATHETER DEVICES

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Introduction: A Closed Suction Catheter (CSC) device is a closed-circuit, multiple-use, in-line tracheal suctioning system designed for use in the patient requiring mechanical ventilation. While previous in-vivo studies have reported the patient benefit of CSC devices, the in-vitro performance characteristics of CSC devices have not been tested. We evaluated four CSC devices in the laboratory to determine whether changes in airflow, secretion fluid levels, and positive and negative pressures influence the device performance characteristics. **Methods**: The six CSC devices selected for testing included the Cath-Guide, swivel (HS) and tee (HT) (Hudson RCI, Temecula, CA), Trach Care, swivel (BS) and tee (BT)(Ballard Medical Products, Draper, UT), Steri-Cath, tee (ST) (Smith Industries Medical Systems, Keene, NH) Isocath, swivel (VS)(Vital Signs Inc, Totowa, NJ) The following performance tests were conducted with three of each CSC devices: 1) A static pressure leak test across the patient connector of the CSC over an incremental pressure range of 0.5 to 14.0 Kpa, 2) The NPB 7200 Quick Extended Self-Test (QEST) was performed with the CSC device placed in the circuit to determine whether the CSC met the pass or fail criteria, 3) A pressure leak test was performed across the catheter tip to the suction control valve of the CSC when pressurized to 1.4 Kpa, 4) A vacuum surge pressure test was performed across the catheter tip to the suction control valve of the CSC when a vacuum of 12.0 Kpa is applied to determine the peak pressure and rise time 10-90% sec., 5) The patient connector resistive back pressure was measured at flow rates 30 to 120 L/min, 6) A simulated 24 hour secretion clearance test was performed to quantify the amount of simulated secretions fluid removed with a CSC at a vacuum pressure of 12.0 Kpa during a simulated 24 hour usage. **Results:**1) Static Leak Test, leaks were detected at 3.0, 6.0, 14 0 and 14.0 Kpa respectively for BT and HT. No leaks were detected with the ST Leaks were detected at 0.5, 1.5, 3 0 ,6 0, 14 0 and 14.0 Kpa respectively for VS and BS No leaks were detected with HS, 2) QEST Test, all CSC devices successfully passed the QEST except for the VS device, 3) Pressure Leak Test, all CSC devices exhibited no measurable leaks except for the VS device, 4) Vacuum surge pressure test, the peak pressure/ rise times were 11.8,/1.5, 13 0,/0.1, 12.7,/0.1, (Kpa, 10-90% sec) respectively for HT, BT and ST and 12.0/1.6, 13.0/.0.3, 13.0,/0.1 (Kpa, 10-90% sec.) respectively for HS, BS, and VS, 5) Patient Connector Resistance Test, measured the back pressures was 0.23, 0 30, 0.73 (cmH2O) respectively for HT, BT, ST and 0.75, 0 43, 0.55 (cmH2O) respectively for HS, BS, VS devices, 6) Simulated 24-Hour Secretion Clearance Test,the amount of fluid measured was 33 6, 35.9, 39.1 ml. respectively for HT,BT,STand 35.5, 35.6, 30.0 ml respectively for HS, BS, VS devices **Conclusion** Currently, neither quanlitiy control standards or testing standards have established for CSC devices. With this in mind, we designed this study to evaluate commercially CSC devices available at this time. Our testing of the CSC devices found the performance characteristics to be equivalent, excluding the VS device, which did not perform equivalent to the other devices, tested Further studies will be required to support these findings in the clinical environment.

OF-97-116

EVALUATION OF A RESPIRATORY FLOW SENSOR

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Introduction Respiratory monitoring of neonate, pediatric and adult patients in the ICU requires accurate flow and volume measurements. The purpose of our study was to evaluate a new device designed for use during mechanical ventilation. We used a laboratory bench test to determine whether influences caused by flow, pressure, and patient tubing configurations effect the performance characteristics of the neonatal and pediatric /adult sensors of the Ventrak 1550 Respiratory Monitor (Novametrix Medical Systems, Walliford, Conn.). **Methods** We tested the accuracy of 3 Neonatal sensors (Model 7224) and 3 Pediatric/Adult sensors (Model 7222). Flow was generated with wall air as source and controlled with precision rotometers. The volume measurements were made with calibration syringes. Each sensor is intended for single patient use and contains its own calibration data that communicates with the Ventrak. All test conditions were conducted at ambient temperature. The Neonatal sensors were tested across a flow range of 4.0 to 30.0 L/min and volumes of 50mls and 500mls. The Pediatric/Adult sensors were tested across a flow of 20.0 to 180.0L/min and volumes of 50mls, 500mls and 1000mls. Inspiratory flow was evaluated with and without an endotrachael tube (ET) inline and a smooth bore 22 ID tube delivering flow. A 4.0 ID ET was in line (Hudson) with neonatal sensors and a 7.0 ID ET was inline (Mallinckrodt) with the pediatric/adult sensors while flow was measured. The resistive backpressure was measured at each flow rate. Backpressure is measured as the difference between pressure at the sensor inlet and atmosphere pressure using a manometer (Dwyer Instr. Inc. Michigan City IN.). **Results** There was no significant difference in flow measurements with or without the ET inline. Values in table reflect flow measured without an ET tube.

Average of 3 sensors %Error

Set Flow L/min.	4.0	10.	20.	30.	60.	120.	150.	174.*
Neonatal Sensor	5.8	7.0	3.17	1.78				
Pedi/Adult Sensor			4.33	2.11.	.44	3.47	1.53	-.34

Average of 3 sensors Volume Measurement	%Error 50mls	500mls	1000mls
Neonatal Sensor	.667	-.21	
Pedi/Adult Sensor	-3.0	-1.39	1.77

The resistive backpressure for the Pediatric/Adult sensor was 2cmH2O/L/sec. The backpressure for Neonatal sensor was 11.6 cmH20 at .5L/second. **Conclusion** Flow and volume measurement were acceptable for both sensors. The high backpressure measured on the Neonatal sensor was of concern, as was the fact that the *Ventrak displayed measurements were limited at 180L/min. A future performance evaluation of the total system is needed.

OF-97-117

EVALUATION OF FOURTEEN ADULT DISPOSABLE MANUAL RESUSCITATORS.

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We evaluated the performance and safety of fourteen disposable manual resuscitators (DMRs): 1st Response (Sims), Bag Easy (Respironics), Capno-Flo (Kirk Specialty Systems), CPR Bag (Mercury Medical), DMR (Puritan Bennett), Dryden (Gibeck), Lifesaver (Hudson RCI), LSP (Life Support Products), MPR (Hospitak), Pulmanex (Bird Life Design), Spur (Ambu), Vcare (Ventlab), Vital Blue (Vital Signs), Code Blue (Vital Signs). **Method**: We used standards and methods approved by American Society for Testing and Materials (F 920-93, ASTM Committee on Standards, Philadelphia, 1993) and International Organization for Standardization (ISO 8382:1988E, New York, 1988). A Bio-Tek VT-2 Ventilator Tester was used as a lung model with C=0.02 L/cm H_2O [0.20L/kPa] and R=20 cm $H_2O.s.L^{-1}$ (2 $kPa.s.L^{-1}$). **Results**. all of the DMRs met ASTM and ISO standards for V_T (600 mL), f (20/min), and I.E (<1:2). The ASTM and ISO standards specify an FDO_2 of ≥ 0.85 with O_2 reservoir and O_2 flow of 15 L/min and V_I of 7.2 L/min (V_T 600 mL, f 12/min). VCare with bag O_2 reservoir had a FDO_2, mean (SD), of 0.72 (0.02), which was significantly lower ($P<0.05$) than the other ten DMRs with bag O_2 reservoir. FDO_2 for 1st response, MPR, and Vcare with aerosol tube O_2 reservoirs <45 inches long had a mean (SD) of 0.82 (0.02), 0.80 (0.01), 0.69 (0.00) respectively, which was significantly lower ($P<0.05$) than 7 DMRs with aerosol tube O_2 reservoirs with lengths ≥45 inches. 1st Response, DMR, and VCare with tube O_2 reservoirs in the collapsed storage position had a FDO_2, mean (SD), of 0.73 (0.00), 0.68 (0.01), and 0.69 (0.01). When tested with simulated vomitus all DMRs were able to be restored to proper function within 20 seconds. All DMRs passed tests for O_2 flow of 30 L/min, forward and backward leakage, drop from 1 meter, and 10-second immersion-in-water. All DMRs except MPR passed the test for expiratory resistance (pressure <5 cm H_2O). Capno-Flo, Dryden, MPR, Pulmanex, and Vital Blue failed the test for inspiratory resistance (pressure <-5 cm H_2O). The BagEasy, DMR, Lifesaver, and Spur were the only DMRs that met specifications for user manual. BagEasy, Code Blue, CPR Bag with tube reservoir, Lifesaver, and Vital Blue with bag reservoir were the only DMRs that prevented accidental disassembly. **Conclusions**: We conclude that BagEasy, DMR, Lifesaver, and Spur met ASTM and ISO standard specifications tested in this study. The other ten DMRs were out of compliance with one or more ASTM and ISO requirements.

OF-97-119

LABORATORY EVALUATION OF ARTIFICIAL NOSES

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Introduction Artificial noses (AN) are passive humidification devices used to condition inspired gases during mechanical ventilation. We evaluated the moisture output (MO), resistance (Raw), and deadspace (DS) of four AN's according to the ISO standard (ISO 9360.1992) Methods: A patient model consisting of a cascade humidifier, temperature controller, 2 test lungs and a series of tubing and one way valves to separate inspiratory and expiratory flows was constructed. This model was ventilated using compressed air (absolute humidity < 0.7 mg/L) at: 1) V_T = 500 mL and f = 20 b/min, 2) V_T = 1000 mL and f = 10 b/min; and 3) V_T = 1000 mL and f = 20 b/min. During ventilation gas exiting the patient model was controlled to maintain a temperature of 34±1°C. The ventilator used a square flow waveform and I:E of 1:2. The model was weighed and then ventilated for 3 hrs and weighed again to determine water loss (mg/L) Three of each AN were tested for three hours at each ventilation setting and the water loss determined (9 devices each were tested). Moisture output was determined by the ISO equation moisture output = 37.6 x (1- water loss with AN/mean moisture loss without AN). Resistance was determined by monitoring pressure drop across each device using a RT-200 calibration analyzer (Timeter) at a flow of 1 L/s. Results at V_T = 1000 mL and f = 10 b/min are shown. Moisture output = mg H_2O/L, resistance = cm H_2O/L/s and deadspace = mL:

Device	Moisture Output	Resistance	Deadspace
Gibeck Compact	30.3 (1.1)	1.9 (0.1)	41 (2)
Pall BB100	25.1 (1.4)	2.1 (0.1)	90 (2)
King 1000	26.1 (1.0)	2.0 (0.1)	29 (1)
Nellcor PB HME	28.9 (1.6)	1.6 (0.2)	89 (3)

Conclusions: The AARC Consensus Conference on Mechanical Ventilators recommends a minimum absolute humidity of 25 mg H_2O/L. The devices tested demonstrate the ability to reach this value. Our results demonstrate that hygroscopic devices are able to deliver more moisture despite a smaller deadspace. This is important when these devices are used with spontaneously breathing patients. None of the devices exceeded the maximum resistance of 5 cm H_2O/L/s established by ISO. Practitioners should be aware of the performance of AN's prior to use.

OF-97-129

NOVEL PULSE OXIMETRY TECHNOLOGY CAPABLE OF RELIABLE BRADYCARDIA MONITORING IN THE NEONATE.

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Pulse Oximetry determines oxygen saturation by comparing the absorbance of light at two wavelengths during pulsatile blood flow. In addition, pulse rate is calculated from the resultant photoplethymosgraphic waveforms. Pulse oximetry is widely used in the Neonatal Intensive Care Unit (NICU). However, its use is greatly affected by motion artifact and low perfusion. Clinicians are often confronted with numerous false alarms and have become accustomed to "verifying" SpO_2 values by correlating the pulse oximeter's pulse rate to the ECG heart rate. The Masimo Corp. (Irvine, CA) has developed Signal Extraction Technology (SET) that calculates a noise reference and uses adaptive filters to cancel interfering artifact. This eliminates interference in the signal and, therefore, is designed to provide a more accurate SpO_2 and pulse rate measurement. This study evaluates Masimo SET's capability of monitoring pulse rate in the NICU. Ten neonates (1,620 to 3,384 grams) were enrolled in the study. Masimo and Nellcor sensors were placed on either foot. The Masimo sensor was attached to a Masimo engineering prototype pulse oximeter, and the Nellcor sensor attached to a Nellcor N-200. Each infant was monitored for 3 to 4 hours; then the sensors were switched to the opposite foot and monitored for the same amount of time. ECG information was interfaced from the SpaceLabs central monitor. All data was collected via serial connection to a laptop computer and operated by a trained observer. Infant motion, physician, nursing and/or therapist interventions, parental care, and low ECG heart rate value during true bradycardias(HR < 100 bpm) were identified. A total of 65.3 hours of monitoring time was accumulated and examined for true and false bradycardic events (bradys).

	N-200		Masimo SET	
	events	alarm time*	events	alarm time*
# of true bradys caught	9(68%)		16(100%)	
# of false bradys	96	86.4 min.	5	0.7 min.
# of "zero outs"	190	97.3 min.	4	1.1 min.
total false alarms/time	286	183.7 min.	9	1.8 min.
* alarm time is defined as the amount of time the pulse oximeter would have been alarming falsely if not silenced by a clinician.				

The frequency and duration of the low pulse rate false alarming of the Nellcor N-200 was more than 30 times greater than the Masimo SET unit. The data suggests that the Masimo SET pulse rate algorithm minimizes false alarms seen in the NICU and captures more true bradycardic events when compared to a conventional pulse oximeter. This supports the utilization of pulse oximeters incorporating Masimo SET in the NICU setting and potentially transport, as well as Step Down units or home care settings where oxygenation and pulse rate monitoring are needed and more sophisticated Central monitoring is not available.

OF-97-134

THREE HUMIDIFICATION TECHNIQUES DURING PEDIATRIC VENTILATION

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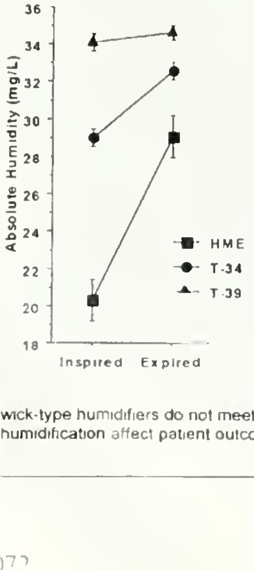
Introduction We sought to determine the inspired and expired absolute humidity (AH_I & AH_E) during the use of a heat and moisture exchanger (HME) and a wick humidifier at two different temperatures during pediatric mechanical ventilation. **Methods:** A measurement chamber was constructed that isolated inspiratory flow and fit between the ETT tip and the ventilator circuit. AH_I and AH_E were measured using a polymer film capacitive sensor with a built-in heating coil that controlled sensor temperature to 47 degrees C to avoid condensation. Eligible subjects included any stable patients ventilated in our PICU who did not have asthma, BPD, cavitating lung disease, or CF. After informed consent, each patient was studied for two hours under all three of the following conditions in random order: (1) use of an HME (Gibeck Humid-Vent), (2) use of a wick-type humidifier set at 34 degrees (Fisher-Paykel), or (3) use of a wick-type humidifier set at 39 degrees. The HME's were sized according to patient tidal volume and placed distal to the measuring chamber. Humidity measurements were taken at the start of each arm and every 30 minutes and were averaged for each patient. Differences were tested for statistical significance (P<0.05) using ANOVA. **Results** Thirteen patients have been studied so far (median age = 5.7 yrs) We discovered statistically significant differences in AH_I between all three arms and in AH_E between the HME and T-34 arm. There were also statistically significant differences between AH_I and AH_E within each arm except the 39 degree arm. **Discussion:** The HME's are far below the output of the heated humidifiers and do not meet published recommendations of >28 mg/L (Branson et al. Respir Care 1996,41 736-743), and thus are probably unsuitable for use in pediatric patients. ASTM 1690 and ISO 8185 standards for heated humidifiers say that all such devices should be capable of producing AH_I of 33 mg/L. Operated at 34 degrees, these wick-type humidifiers do not meet that standard. Whether the differences in humidification affect patient outcomes has not been determined.



OF-97-135

THE EFFECTS OF VARYING SET HUMIDIFIER TEMPERATURE AND VENTILATOR FLOW RATE ON THE RELATIVE HUMIDITY DELIVERED BY THE HUDSON RCI CONCHATHERM IV HEATED HUMIDIFIER

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This study examined the effect of varying ventilator flow rate and set humidifier temperature on the relative humidity delivered by the Hudson ConchaTherm IV heated humidification system. Methods. A ConchaTherm IV heated humidifier (Hudson RCI Model 400-00, Temecula, CA ** unit contained a recent software upgrade incorporated in all production units) equipped with a low compliance humidification chamber (Hudson RCI Model 780-32) and 72" dual heated wire circuit (Hudson RCI Model 382-30) was attached to a Hamilton Veolar (Reno, Nevada) mechanical ventilator. The mechanical ventilator was placed in the volume control mode with a square inspiratory flow wave form and set tidal volume of 1.0 liter. A heated humidity chamber (HC), 37.1 C° (± 2.2 C°), was constructed to accommodate the probe of a capacitance type digital hygrometer (Curtin-Matheson Scientific, Model # 244-355, Brisbane, CA). Inspiratory gas passed through the HC* for relative humidity measurement. The heated wire controller was set for 0 C° temperature differential between the humidifier chamber and the proximal airway. A thermocouple thermometer (Baxter Inc., Duo Temp, Round Lake, IL) continuously displayed temperature from two areas within the ventilator circuit 1) adjacent to the Hudson RCI ConchaTherm IV humidifier chamber temperature probe and, 2) adjacent to the humidifier temperature probe on the inspiratory side of the patient wye. Stabilized, repeat measures were collected at 1 minute intervals until 5 measurements at each variation of temperature and set ventilator flow rate were complete. Prior to testing all equipment was calibrated to the manufacturer's specifications. Results. Data was analyzed using Analysis of Variance (ANOVA). Statistical significance existed within and between all groups p < 0.05

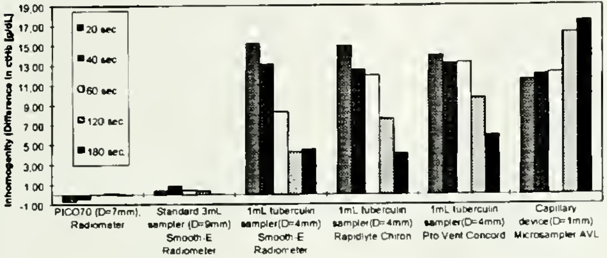
Set Temperature (C°)	Ventilator Flowrate (L/min)	Hygrometer Temperature (C° ±SD)	Relative Humidity (% ±SD)	Absolute Humidity (mg H_2O/L ±SD)
32	40	31.57 (±0.20)	95.49 (±0.35)	31.56 (±0.33)
34	40	33.61 (±0.21)	92.48 (±0.61)	34.14 (±0.61)
36	40	35.01 (±0.16)	96.93 (±2.82)	38.39 (±1.07)
38	40	37.03 (±0.08)	100.0 (±0.00)	44.08 (±0.17)
32	60	31.66 (±0.08)	93.88 (±0.30)	31.25 (±0.16)
34	60	33.21 (±0.07)	98.08 (±0.36)	35.41 (±0.25)
36	60	35.10 (±0.08)	100.0 (±0.00)	39.73 (±0.03)
38	60	36.31 (±0.72)	100.0 (±0.00)	42.50 (±1.57)
32	80	31.38 (±0.15)	95.45 (±0.75)	31.31 (±0.23)
34	80	33.26 (±0.09)	98.80 (±0.31)	35.77 (±0.20)
36	80	35.37 (±0.36)	100.0 (±0.00)	40.21 (±1.02)
38	80	36.28 (±0.16)	100.0 (±0.00)	42.48 (±0.35)
32	100	31.36 (±0.08)	95.81 (±0.37)	31.34 (±0.13)
34	100	33.25 (±0.09)	99.03 (±0.32)	35.80 (±0.21)
36	100	35.30 (±0.12)	100.0 (±0.00)	39.79 (±0.02)
38	100	36.97 (±0.11)	100.0 (±0.00)	43.69 (±0.67)

Conclusion. The Hudson RCI ConchaTherm IV met the American National Standards Institute (ANSI) heated humidifier output standard of 30 mg H_2O/L under all test conditions

OF-97-144

NEW SMALL VOLUME ARTERIAL BLOOD SAMPLER WITH UNIQUE MIXING CAPABILITIES. Michael Vester and Peter Brondum, Radiometer Medical A/S, Copenhagen, Denmark **Backgroud** Inadequate mixing of settled samples is a common and often overlooked preanalytical error that may severely bias measuring results Inhomogeneity of samples is impossible to detect visually due to the strong coloration of hemoglobin and thus is often not recognized In designing the new arterial blood sampler, PICO^{TM}70 (Radiometer Medical A/S), an important aim was to construct a sampler that would combine a small sample volume with optimal mixing capabilities This aim was reached with an optimized barrel diameter (D) and the use of a heparin disc working as a stirring device **Materials and methods:** The PICO^{TM}70 (D=7 mm) was compared with three 1 mL tuberculin samplers (D=4 mm)(Smooth-E Radiometer, Rapidlyte Chiron (Manufactured by Marquest Medical Products Inc), Pro Vent Concord), a 3 mL sampler (D=9 mm, Smooth-E Radiometer), and a capillary device (D=1 mm, Microsampler AVL) with respect to mixing capabilities. The test was carried out as a worst case situation with 1 mL of fully settled and cooled (4 °C) blood in each sampler (2 mL in the 3 mL sampler and 220 µL in the capillary device) Mixing was performed by the recommended combination of a rotator and rolling between the palms After a total mixing time of 20, 40, 60, 120, and 180 seconds the *c*tHb was measured on an OSM^{TM}3 on samples from the top (0 9 mL mark) and from the bottom of the sampler (0.3 mL mark). 120 samplers were tested **Results:** The mean difference between *c*tHb measurements at the bottom and at the top of the samplers was calculated for each mixing time and set as an expression of homogeneity of the sample (Figure). As seen the PICO^{TM}70 has mixing capabilities that are only matched by those of a 3 mL sampler Presumably the heparin disc is working as a stirring device thus compensating for the small barrel diameter of the PICO^{TM}70 All tuberculin samplers show poor mixing capabilities as a direct consequence of the small diameter. The capillary device included in the test proved impossible to mix. **Conclusion:** PICO^{TM}70 has an optimal construction that combines the possibility of a small sample volume (0.3 mL - 1 5 mL) with mixing capabilities similar to those of a 3 mL syringe

Mixing Characteristics



OF-97-145

EVALUATION OF SENSICATH^R BLOOD GAS MEASUREMENT SYSTEM FOR POINT-OF-CARE SUPPORT Lauren Stapp, RRT, Shari Bailey, RRT, Paul Loik, RRT, Linda Folk, RRT, Ronald Dechert, MS, RRT Critical Care Support Services, University of Michigan Medical Center, Ann Arbor, MI **Introduction:** Analysis of arterial blood gases are important to provide appropriate and timely therapeutic management of the mechanically ventilated critical care patient. Historically, this service (ABG's) has been provided through central or satellite laboratories which resulted in increased delays associated with sample transport, analysis and reporting To decrease the turn-around-time (TAT) associated with STAT blood gas analysis, POC centers have been developed The purpose of these POC's is to place ABG analysis as close to the patient as possible An extension of the POC philosophy is the development of patient attached analyzers which allow immediate access to arterial blood samples and blood gas analysis. We evaluated the Sensicath^R Blood Gas Measurement System (Optical Sensors Incorporated, Eden Prairie, MN) to determine the bias and error compared to conventional bench top blood gas analysis **Methods:** Sixteen mechanically ventilated adult patients admitted to our intensive care units were selected for this comparative trial. A SensiCath^R Blood Gas Measurement System was attached to the arterial line of each patient following calibration of the sensor Arterial blood gas measurements were obtained per routine patient management The arterial blood gas readings from the SensiCath^R were recorded immediately preceding the collection of the arterial samples All arterial samples were analyzed using an Instrumentation Laboratories Blood Gas Analyzer (IL model 1640) A total of 64 comparison blood gas measurements were used for this study The bias and error of the SensiCath^R was determined using the technique described by Bland and Altman **Results:** We found excellent correlation between the values obtained from the SensiCath^R and our reference analyzers The correlation's were PO_2, r^2=0 97, p<0 05, PCO_2, r^2=0 86, p<0 05 and pH, r^2=0 86, p<0 05 The observed bias (SensiCath^R-reference)and error for each analyte were -0 8 torr ± 12 torr for PO_2, 1.5 torr ± 3 torr for PCO_2 and 0 01 ± 0 03 for pH **Conclusions:** The SensiCath^R Blood Gas Measurement System provides reliable blood gas analysis when compared against conventional reference analyzers. The patient attached characteristic of this analyzer may be desirable in patient populations which require minimal blood loss A complete cost analysis is warranted to determine the feasibility of using this system

OF-97-156

EVALUATION OF THE PARATREND 7 BLOOD GAS ANALYSIS SYSTEM IN ADULT PATIENTS WITH ARDS Linda Folk, RRT, Lauren Stapp, RRT, Paul Loik, RRT, Ronald Dechert, MS, RRT Critical Care Support Service, University of Michigan Medical Center, Ann Arbor, MI **Introduction:** Titration of PEEP and FiO_2 are common adjustments used during therapeutic support of adult patients with severe ARDS These ventilator adjustments require frequent monitoring of arterial blood gas values to determine the efficacy of the care Use of continuous indwelling blood gas catheters may be useful for patients who require frequent ventilator adjustments We evaluated the Paratrend 7 blood gas catheter to determine the bias and error compared against our conventional reference analyzers **Methods:** Six patients admitted to our intensive care units for ARDS were selected for this comparative trial. A Paratrend 7 (Diametrix Medical, Inc) probe was calibrated and inserted through a radial artery catheter Arterial blood gases were obtained as part of our routine ventilator support The values displayed on the Paratrend monitor were recorded (PO_2, PCO_2, pH) and compared against the reference values obtained from our Point-Of-Care (POC) center (IL model 1640) A total of 49 comparisons were collected as part of this evaluation. The data was analyzed using the procedure described by Bland and Altman. **Results:** We observed significant correlation's for all the analytes between the Paratrend 7 and our reference analyzer However, the correlation between the Paratrend and reference analyzer was lowest for PO_2 (r= 0 701, p<0 05) The correlation for PCO_2 and pH were r=0 969, p<0 05 and r=0 933, p<0 05, respectively The bias and error for each analyte comparison are shown in the table below

	PO_2	PCO_2	pH
Bias	-3 torr	2 torr	-0 02
Error	19 torr	7 torr	0.06

Conclusions: The Paratrend 7 blood gas analyzer system offers continuous analysis of blood gas through the use of an indwelling probe Our initial pilot study demonstrated significant correlation's, bias and error when compared against conventional analyzer results However, PO_2 appeared to be the most erratic analyte Further studies are warranted to determine the application and cost effectiveness of this technology

OF-97-155

COMPARISON OF ESOPHAGEAL DOPPLER AND THERMAL DILUTION CARDIAC OUTPUT IN CRITICAL CARE PATIENTS Paul Loik RRT, Allan Andrews MS,RRT, Linda Folk RRT, Lauren Stapp RRT, Ron Dechert MS, RRT, Shari Bailey RRT- Critical Care Support Services-University of Michigan Medical Center- Ann Arbor, Michigan **Introduction:** Hemodynamic monitoring is an important adjunct to therapeutic support of the critical care patient The use of pulmonary artery catheters have been an integral part of hemodynamic monitoring to allow assessment of fluid status and cardiac performance Recent criticism of PA catheters have questioned the efficacy of this monitor Esophageal doppler technology may provide functional assessment of hemodynamic status with little or no risk for the critically ill patient A new esophageal doppler monitor (EDM, Deltex Medical Incorporated, Irving Tx) has been introduced to provide continuous hemodynamic monitoring in patients who may not warrant PA catheters The purpose of this study was to evaluate the bias and error of cardiac output monitoring using the EDM system. **Methods:** Patients who required PA catheters and CO measurements as part of their routine clinical management were selected Sixteen patients were originally recruited for this study Three patients were excluded from final analysis due to signal distortion Thirteen nonrandomized mechanically ventilated adult patients were selected for this comparison trial An EDM probe was placed according to the manufacturers guidelines Nasal placement was the preferred route whenever possible The cardiac output values obtained from the EDM were compared to values obtained from thermal dilution cardiac output measurements taken at the same time A total of 24 comparisons were obtained from this study population. Bias and error were determined using the statistical analysis described by Bland and Altman The results are presented in the following discussion **Results:** We found excellent correlation between the cardiac output values obtained from the EDM when compared against our clinical standard, bolus thermal dilution The observed correlation was r2=0.74, p<0 05 The bias (EDM-TD) and error observed were 0 125 L/min and 1 18 L/min respectively The mean cardiac output for all comparative results was 5 85 L/min with a range of 2 8 to 10 95 (EDM+TD / 2) L/min **Conclusions:** The Deltex EDM provides comparable values as those reported by TD in critical care patients In addition, the EDM allows continuous monitoring of flow which may allow improved therapeutic assessment

OF-97-172

USE OF CCO, SPO2, AND SVO2 TO DETERMINE ENERGY EXPENDITURE: HOW RELIABLE IS IT?

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Introduction. Currently, indirect calorimetry is the most accurate and useful technique for determination of energy expenditure (EE) in the ICU population Indirect calorimetry is preferred over the circulatory calculation of EE in the critically ill because the Fick equation requires parameters that involve sampling of arterial and mixed venous blood and thermal bolus injection for cardiac output determination. With the introduction of pulse oximetry and oximetric pulmonary artery catheters that employ continuous cardiac output (CCO) technology, however, the parameters needed for calculation of the Fick equation can be easily obtained without such costly and time consuming analysis. If the circulatory calculation of EE through the use of CCO, pulse oximetry, and mixed venous oximetry can provide accurate patient results, use of indirect calorimetry in the ICU could be diminished extensively **Methods** All mechanically ventilated patients admitted to the Trauma Burn Emergency Service who required pulmonary artery catheterization (Baxter Edwards Swan-Ganz CCO/SvO2/VIP TD, models 7468F and 746H8F, Baxter Healthcare Corporation, Edwards Critical Care Division, Irvine, CA) were considered for inclusion in this comparative study Comparison date points were collected whenever EE through indirect calorimetry was warranted per ICU protocol. Each data point consisted of the following information: CCO, SvO2, SpO2, VO2 and EE values obtained from the metabolic cart (Sensormedic Delta Trac, Sensormedics, Yorba Linda, CA), and Hgb obtained from the daily SvO2 calibration. Fick VO2(mL/min) was calculated as [CCO x (CeO2-CvO2) x 10] with CaO2 = Hgb x 1.34 x SpO2 and CvO2 = Hgb x 1 34 x SvO2 The portion of dissolved oxygen in plasma was not added to the equation since no PeO2 was obtained. EE was calculated from VO2 results. Bias and error were determined using the technique described by Bland and Altman. **Results**: 19 patients were included in this comparative study A total of 42 date points were collected EE calculated from CCO, SpO2, and SvO2 underestimated the values obtained from our reference standard with bias = -325 kcals/24 hours and error = 871 kcals/24 hours. We did not observe a significant correlation between the calculated EE and measured EE (r^2=0.19).

Conclusion Use of CCO, SpO2, and SvO2 to calculate energy expenditure produced a relative error of 30-35% when compared against our clinical standard. Due to the significant relative error and lack of appropriate correlation, we cannot recommend the use of these continuous monitors to obtain energy expenditure in critical care patients Determination of energy expenditure in this patient population must be obtained from dedicated metabolic carts

OF-97-173

AN EVALUATION OF THE VOLUME AND PRESSURE DELIVERY CHARACTERISTICS OF THE FRENCH POCKET EMERGENCY AIRWAY (FPEA) AND THE NU-TRAKE (NT) CRICOTHYROIDOTOMY DEVICE

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Background: Cricothyroidotomy, the puncture of the cricothyroid cartilage to create an airway, is usually performed in an emergency situation wherein the victim has clenched teeth, blood or vomit obscuring visualization of the upper airway, severe maxillofacial injuries, inaccessibility because the victim was trapped, severe burns, laryngeal edema from an insect bite, or failure of the Heimlich maneuver The present report describes a new cricothyroidotomy device that is packaged as a key ring attachment This new device is compared with the currently available NT cricothyroidotomy device We sought to determine the volumes and pressures generated with this new device compared to the NT The FPEA is a four-piece device that is disassembled for cricothyroidotomy, then reassembled for patient ventilation The NT is a needle cricothyroidotomy device, that uses airways of increasing size for patient ventilation. **Methods:** Each device was punctured into a piece of corrugated tubing closed at one end, simulating a cricothyroid membrane The tubing was adapted to a training test lung (TTL) which was ventilated through each device by 1) a mechanical ventilator set at a tidal volume of 0 8 L, 8-16 breaths/min and flows of 30 and 50 L/min, 2) a manual resuscitator at rates of 10-20 breaths/min, and 1-2 sec inspiratory times and 3) by mouth-to-device at 10, 12, and 20 breaths/min and 10 and 20 cm H_2O These settings are consistent with Advanced Cardiac Life Support guidelines Pressures, flows, and volumes were measured by the TTL **Experience:** The device was only tested in-vitro Clinical trials were not part of this protocol **Evaluation results:** The FPEA delivered 0 704 ± 0 003 L to the test lung at all rates and flows The NT, with tape wrapping to cover the leaks inherent in the device delivered 0.475 ± 0 035 L to the test lung at all rates and flows The FPEA delivered 0 535 ± 0 013 L and the NT delivered 0 429 ± 0 005 L during manual ventilation with the resuscitator Tidal volume was approximately 0 9 L with the FPEA during mouth-to-device breathing at a peak pressure of approximately 20 cm H_2O and 0 45 L at a peak pressure of 10 cm H_2O The NT volumes were 0 704 L and 0 626 L at 20 cm H_2O and 0 481 L at 10 cm H_2O with mouth-to-device ventilation Using the FPEA, intrinsic PEEP began to develop at 10 breaths/minute and actual flow of 27 5 L/min When flow was increased to 44 L/min , the intrinsic PEEP was eliminated Higher intrinsic PEEP occurred at each higher breath rate at a set flow of 30 L/min which decreased with a set flow of 50 L/min The highest intrinsic PEEP was 4 5 cm H_2O at 16 breaths/min and set flow of 30 L/min This decreased to 1 8 cm H_2O when flow was increased to 50 L/min **Conclusions:** The FPEA delivered consistent tidal volumes to the test lung at all rates and flows selected when mechanical ventilation was used Ventilation was consistent when ventilating with a manual resuscitator and with mouth-to-device ventilation Results demonstrate that the volumes through the FPEA were consistently higher than those delivered through the NT due to leaks inherent in the NT, despite wrapping the NT with cloth adhesive tape While both devices appear to create a patent airway, ventilation through the FPEA was greater, as it did not leak and its seal with the simulated airway was superior to that of the NT Clinically inconsequential intrinsic PEEP developed when the FPEA was used Both the NT and FPEA provide a 15mm O D adapter for attachment of ventilatory devices

OF-97-181

COMPARISON OF SECRETION RETRIEVAL: SINGLE USE CATHETER VS MULTIUSE CATHETER AND SIGH VS MANUAL BREATH

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Introduction Inline multiuse suction catheters (IMU) have been on the market for over 10 years. While they seem to be beneficial in reducing the risk of unintentional contamination of the patients airway and very likely protecting the healthcare provider, some practitioners feel they are not as efficient at secretion removal as a single use (SU) catheter. The purpose of this study was to evaluate the secretion retrieval capabilities of a SU catheter and IMU catheter. **Method:** Study Design 1: Ten patients were selected from the Critical Care Medicine Unit of a University Hospital. They were selected based on three criteria: the diagnosis of pneumonia, hemodynamic stability and stable ventilator settings (FIO_2 < .60 and ≤ 5 PEEP). Each patient was suctioned every two hours x 4, alternating between the IMU (TrachCare, 14 Fr., Ballard Corp) and the SU catheter (Davol Suction Catheter, 14-16 Fr., C.R. Bard Inc., Cranston, RI). Each suction session was identical in number of passes, volume of instilled normal saline, FIO_2 (1.0)and sigh breaths (1.5 times V_t). When the patient was suctioned with SU catheter, they were removed from the ventilator during suctioning and returned to the ventilator in-between passes with sigh breaths Sighs were also used in-between passes when using the IMU. Pulse oximetry was measured on all patients during the procedure Secretions were collected in identical sputum traps and weighed and measured Study Design 2: Ten patients were selected as in Study 1. Patients were suctioned every two hours x 4 using only the IMU (Concord Sten-Cath, 14 Fr., Keene, NH) alternating removing the patient from the ventilator, manually ventilating ten times and returning the patient to the ventilator to suction, with sighing the patient ten times in-between passes at 1.5 times the V_t. Secretions were collected, weighed and measured in the same manner as study 1. In Study 2, all volumes, pressures and flows were measured with the BICORE C-P 100 Pulmonary Monitor (BICORE Monitoring Systems, Irvine, CA). **Results:** Study Design 1: All patients tolerated both methods well with no incidences. There was no statistically significant difference between the SU or the IMU catheter in weight or volume (p= .840 and p= .664 respectively). Study Design 2: All patients tolerated this study well with no incidences. There was no statistically significant difference between using the ventilator with sigh breaths or manually ventilating in between passes (p= .095, p= 224 respectively). There was a statistically significant difference in the peak inspiratory pressure (mean 41 ± 9.3 vs 49 ± 6.5 respectively), peak inspiratory flowrate (1.11 l/m ± .16 vs 1.36 l/m ± .13) and inspiratory volume (1.09 ml ± 23 vs .94 ml ± .08) between the two methods (p= 003, p= .003, p=.03 respectively). **Conclusion**: There is not a statistically significant difference in secretion retrieval when using a SU or IMU or when using manual ventilation or mechanical ventilation with sigh breaths to hyperoxygenate the patient. This would suggest that practitioners do not need to remove patients from mechanical ventilation to suction provided the ventilator has 100% FIO_2 and sigh capabilities

OF-97-174

COMPUTER SIMULATION OF LUNG VOLUMES AND VENTILATORY CAPACITIES USING ANTHROPOMETRIC DATA OBTAINED ON THE ANTHROPOMETRIC MEASURING CHAIR (AMC)

by Z Balantič*, M Fležar**, P Novak*, J Šorli**, F Kandare** *University of Ljubljana, Faculty of Mechanical Engineering **Clinical Centre Ljubljana, Clinic of Internal Diseases—Golnik Slovenia

We sought to validate unconventional anthropometric values that can be obtained in paralyzed patients seated in a special chair (AMC) as predictors of ventilatory function (FVC, FEV1, TLC, RV) in order ultimately to establish reference values for handicapped subjects We studied 45 healthy adults, measuring lung function with spirometry and plethysmography Multiple stepwise regression analysis incorporating 21 unconventional anthropometric variables significantly correlated with conventional measures (age mass, height) led to equations for prediction of FVC, FEV1, TLC, and RV in men and women SH=sitting height, A=age, ST=sternum length, CDX=difference in expiratory & inspiratory chest circumference at xiphoid, AS=armspan,CIX=inspiratory chest circumference at xiphoid, LLEX=expiratory laterolateral chest diameter at xiphoid, APD5=diff in anteroposterior expiratory & inspiratory diameter at 5th vertebra, LLI5=inspir chest diameter at 5th vertebra CD5=difference in insp & expir diameter at 5th vertebra. APIX= inspir anteroposterior diameter at xiphoid LLDX=diff in inspir & expir laterolateral chest dia at xiphoid,LLE5=expir laterolateral chest diameter at 5th vertebra

Women. FVC=30 311SH-30 222A+117 981ST+76 729CDX [R^2=0.989SD=494 mL]

Men FVC=33 584AS-86 489CIX+222 768LLEX+211 001APD5 [R^2=0 991 SD=550 mL]

Women FEV1=-10 356SH-134.667LLI5+46 217AS+151.603CD5 [R^2=0 991SD=363 mL]

Men FEV_1=81 242SH-92 415CIX+130 229LLEX+109 338ST-185 832CDX+86 066CD5 [R^2=0 993 SD=387 mL]

Women TLC=63 408SH-82 485APIX+108 962ST [R2=0 989 SD=643 mL]

Men TLC=55 596AS-128 506LLDX+256 730ST-58 878CIX-329 307CDX [R^2=0 093 SD=687 mL]

Women RV=149 695LLE5-138 072APIX+12 943A [R^2=0 966 SD=342 mL]

Men RV=-1.366APE5+11 665A-71 498LLD5+130 313ST-153 040CDX [R2=0 980 SD=373 mL]

Unconventional anthropometric variables obtained using the AMC chair can be used to predict lung volumes in adults.

OF-97-185

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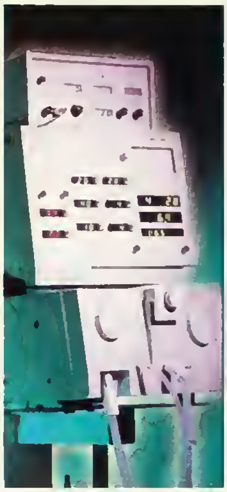

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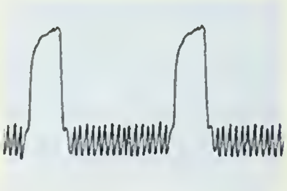

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PREDICTORS OF COMPETENCE IN METERED DOSE INHALER KNOWLEDGE AND TECHNIQUE IN FOUR HEALTH PROFESSIONS

Tammy K Sleeper BS RRT *, Jon Gietzen BS RRT, Darrin Beier BS RRT, *Arkansas Children's Hospital, Little Rock, AR, North Dakota State University/ MeritCare Resp Care Program, Fargo, ND 58122

INTRODUCTION: Correct use of metered dose inhalers (MDI) is very technique and knowledge dependent. Given the diverse educational backgrounds of the four professions studied, we sought to determine whether demonstrable differences in MDI technique or knowledge in these care givers exist, and if we could predict competence based on training, frequency of MDI use and years experience. **METHOD:** We studied MDI technique and knowledge of randomly selected MD's (13), RN's (15), RPH's (14) and RT's (14) *[56 subjects]* from a 400+ bed regional teaching facility and local retail pharmacies. Consent was implied by participation. Each subject answered seven questions to determine their knowledge of common MDI facts. The subject, using a clean placebo inhaler, also demonstrated their MDI technique. **RESULTS:** Data was analyzed, using one way ANOVA (p<.05) and Tukey (HSD) comparison of means (alpha<.05) All data reported as % correct *Mean (sd).*

		MD	RN	RPH	RT
KNOWLEDGE	Know when MDI is empty	54	47	64	93
	Inhale with slow inspiration	1.0	.93	1.0	.79
	Spacer effect on mouth deposits	77	1.0	.64	1.0
	When to rinse mouth	.85	93	79	1.0
	First Beta2, Second steroid	69	33	57	93
	Effect of waiting between puffs	.69	67	57	93
	% of aerosol deposited in lungs	15	.07	.00	.29
	Mean % Correct Knowledge	.67(.16)	63(.14)	60(.10)	.84(.13)
TECHNIQUE	Shake prior to use	85	.80	1.0	1.0
	Exhale fully prior to actuate	.23	33	29	79
	Hold MDI upright when using	1.0	1.0	93	1.0
	Use some type of spacer device	1.0	1.0	93	1.0
	Begin inspiring before actuate	.77	80	29	1 0
	Actuate MDI	92	1.0	1 0	1.0
	Inspire with slow deep breath	.92	93	50	1.0
	Hold breath for >3 seconds	46	.53	.57	1 0
	Only inspire 1 Puff per time	.92	1 0	.79	.93
	Mean % Correct Technique	.78(.11)	82(.11)	71(.13)	97(.05)

PREDICTORS		n	Knowledge	Technique
How Trained	MDI pkg insert	14	60(.09)	.74(.16)
	Formal education	26	.75(.17) p=.01	87(11) p=.01
	Peer education	16	.65(.15)	81(15)
MDI Frequency	<10X per week	35	64(.14)	77(15)
	>10X per week	21	.75(.18) p=.09	90(.09) p=.01
Experience	<15 years	26	68(.17)	85(.12)
	>15 years	30	.69(.15) p= 19	79(15) p=.15

CONCLUSION: There is a significant difference in the overall knowledge and technique (p=.0001) between professions, with RT scoring significantly higher. Formal education, and MDI frequency >10 X per week predict greater competence in technique. Only formal education predicts increased knowledge. We conclude, in our facility, formal education is the best option for ensuring competence in both MDI knowledge and technique.

OF-97-011

CRTT EXAMINATION RESULTS ARE INVERSELY RELATED TO THE NUMBER OF YEARS OF CLINICAL EXPERIENCE WITHIN THE STAFF OF A LARGE, UNIVERSITY AFFILIATED TEACHING HOSPITAL

Russell T Reid, RRT, CPFT, David Wheeler, RRT, Ken Hargett, RRT, and Cathy Meents, RRT
The Methodist Hospital, Houston, Texas.

We sought to determine if a significant statistical relationship exists between the knowledge, skills and abilities of Respiratory Care Practitioners and the number of years of clinical experience they posses Methods: An entry level CRTT examination, distributed by the National Board For Respiratory Care (NBRC) in a "CRTT Study Guide", was administered to 77 Respiratory Care Practitioners (RCPs) employed by the Respiratory Care Services Department. Statistical analysis consisted of correlation and linear regression with p < 05 considered significant Statistical analysis was performed using a commercially available statistical software package (Exstatix, Select Micro Systems, Yorktown Heights, NY) and results were adjusted for sample size. Results.

Sample Size and Staff Credentials	Mean Experience (± S D)	Mean Examination Score (± S D)	Correlation Coefficient	Coefficient of Determination (r^2)
n=77	9.87 years (± 6.59)	82.51% (± 7.93%)	-0.447	0.200*

* p < 05

The coefficient of determination demonstrates a statistically significant relationship between the staff 's knowledge, skills and abilities and the number of years of clinical experience When adjusted for sample size the number of years of experience accounted for 20% of the differences in test scores The general trend demonstrated was an inverse relationship, with examination scores decreasing with an increasing number of years of clinical experience Conclusion: Many factors account for differences in individual examination scores. Performance on the CRTT examination within our staff was adversely effected by the number of years of clinical experience or from another perspective an increasing length of time from their date of graduation from an accredited Respiratory Care education program. We believe this points to the need for an increased level of continuing education provided either through an accredited program or alternatively by the employer

OF-97-037

EXAMINATION OF ACADEMIC USES OF AN INTERNET SITE: AN ONGOING STUDY

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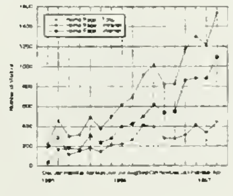
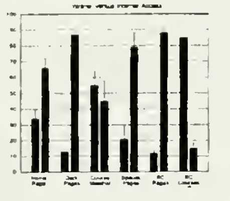
University of Texas Medical Branch, Galveston, Texas

The School of Allied Health Sciences (SAHS) began operating an internet site (http.// www sahs.utmb.edu/sahs) in Dec., 1995. Initially, general information about the School and its Departments was available and in Aug.,1996, course materials were added. The purpose of this study is to determine how visitors access the site and if students would use the site to obtain course materials. Raw data consist of log entries kept by the web server software Log entries are a computer record of each file that a visitor accessed while at our site. The logs are broken down by month, page (School's home page, departmental home pages, etc), and user URL (University's computers = intranet or other URL = internet) Our data, which is updated monthly, indicate the following. The number of visitors to the SAHS home page has increased in a roughly linear fashion, we had over 1,500 visitors in Apr., 1997. The majority of visitors use the internet to access the SAHS home page (currently about 70%) About 42% use commercial internet providers; another 32% use computers at educational sites (these represent a broad cross section of US educational institutions); less than 1% have foreign addresses, and the remainder have only an IP address. Visitors to the departmental pages (those seeking information about our programs) overwhelmingly use the internet (~90%), whereas, visitors (mainly our students) to the course home pages are about evenly split between the internet and the intranet (45/55%) Specialized peges (professional employment opportunities, meeting information, etc) are heavily utilized by internet visitors (~80%) The visitors to the Respiratory Cere's (RC) departmental pages mirror these trends, that is,visitors use the internet (~86%), wherees course materials usually are accessed via the intranet (~85%) The number of visitors to the RC home page is much greater than one would expect based on the number of students in the RC department Our experiences indicate the following. Our web site is a good way to advertise the School. Students will use online resources but currently they favor using the School's intranet We predict that as internet access from home computers becomes more common, educational uses of the internet will increase





OF-97-052

EVALUATION OF THE HEALTH OCCUPATIONS APTITUDE EXAMINATION (HOAE) FOR SCREENING RESPIRATORY CARE EDUCATION PROGRAM APPLICANTS.

Jeff Standridge, MEd, RRT, Kathy Briggs, MEd, RRT, Kathleen M Mugan, MT (ASCP)SH., University of Arkansas for Medical Sciences, Little Rock Arkansas.

INTRODUCTION: In our Respiratory Care Program, attrition rates vary, but periodically approach undesirable levels. To reduce attrition and more accurately predict success, a revision of the current selection procedures was necessary. We evaluated as one possible component of our admissions procedure, the Health Occupations Aptitude Examination (HOAE), an instrument, specifically for use by allied health education programs in admission, placement, and guidance procedures, that contains 5 separate tests. Scores are given for Academic Aptitude (A.A.), Spelling (Sp.), Reading Comprehension (R.C.), Information in the Natural Sciences (N.S.), and Vocational Adjustment Index (V.A.I.). **EVALUATION METHOD:** We reviewed the instrument's technical manual for norms, reliability-validity studies, and general test-development procedures. We then conducted a pilot study using a convenience sample of 49 respiratory care students from 3 different program years. To prevent respiratory care instruction from biasing the examination results, the HOAE was administered immediately upon admission to the Program, before any professional education commenced. Each test score from the HOAE was then correlated with professional respiratory care program grade point average (PrGPA) using the Pearson Product Moment correlation coefficient of 0.40 as a threshold and an α level of 0.05. **RESULTS:** Positive relationships were found between PrGPA and 3 of the 5 instrument tests. Statistically significant relationships were found between the A.A. Score ($r = 0.40$, $p < 0.05$), N.S. Score ($r = 0.40$, $p < 0.05$), and R.C. Score ($r = 0.31$, $p < 0.05$). **CONCLUSIONS:** The potential of the HOAE for strengthening our Program's selection process is not clear, although the V.A.I. provides useful information about specific behaviors and is useful in counseling. We will continue to administer the HOAE in order to determine its ultimate appropriateness as an admissions process component.

OF-97-081

CORRELATING VARIOUS ADMISSION VARIABLES WITH ACADEMIC SUCCESS IN A RESPIRATORY CARE EDUCATIONAL PROGRAM Jeff Standridge, MEd, RRT, University of Arkansas for Medical Sciences, Little Rock, Arkansas **INTRODUCTION:** The literature provides a wealth of information for predicting the success of students entering college from high school. However, predicting a student's success in a Respiratory Care Educational program can be quite difficult. **METHODS:** In an effort to establish a valid admission system for Respiratory Care Program applicants, an analysis of a number of independent variables was conducted. As program success is the ultimate goal of admission selection, these independent variables were correlated with Professional Respiratory Care Program Grade Point Average (PrGPA). A convenience sample of respiratory care students ($n = 49$) was selected from three different program years. The HOAE was administered immediately upon admission to the Respiratory Care Program, before any professional education commenced. The results of the HOAE and several other admission variables were then correlated with ending PrGPA, using the Pearson Product Moment correlation procedure. The admission variables studied were, Interview Score (I.S.), Personal References Score (R.S.), Cumulative Pre-requisite Grade Point Average (CGPA), and all five tests of the HOAE instrument: Academic Aptitude (A.A.), Spelling (Sp.), Reading Comprehension (R.C.), Information in the Natural Sciences (N.S.), and Vocational Adjustment Index (V.A.I.). **RESULTS:** The results of the analysis conflicted with previous theory, making the need for this particular study evident. Using a Pearson coefficient of 0.40 as a threshold (Popham & Sirotnik, 1992), no significant relationships were found between PrGPA and the Interview Score or Reference Rating Score. However, significant correlations were noted between PrGPA and CGPA ($r = 0.42$, $p < 0.05$). In addition statistically significant relationships were found between PrGPA and the Academic Aptitude Score ($r = 0.40$, $p < 0.05$), Information in the Natural Sciences Score ($r = 0.40$, $p < 0.05$), and Reading Comprehension Score ($r = 0.31$, $p < 0.05$). While statistically significant beyond the 0.05 alpha level, the relationship between PrGPA and Reading Comprehension was considered to be quite weak. **CONCLUSION:** In order to strengthen admission decisions for respiratory care program applicants, the use of multiple measures is advantageous. The use of previously valid criteria does not guarantee current or continuous validity. This makes frequent assessment of admission criteria a necessity. While generalization of this particular study beyond the scope of our program is limited, further research into predicting academic and professional success is warranted.

OF-97-082

CAN RESPIRATORY THERAPY EDUCATION IMPROVE CRITICAL THINKING?

Shelley C. Mishoe, PhD, RRT, Franklin H. Dennison, MEd, RRT, RPFT, Medical College of Georgia, Augusta, GA, and Lynda Thomas-Goodfellow, MBA, RRT, Georgia State University, Atlanta, GA.

__Introduction:__ The purpose of this study was to determine if a BS Program in Respiratory Therapy improved students' critical thinking (CT) as measured by the Watson-Glaser Critical Thinking Appraisal (WGCTA). The WGCTA is considered to be the best single measure of critical thinking involving the abilities to define the problem, select information for problem solution, recognize stated and unstated assumptions, formulate or select promising hypotheses, and draw valid conclusions. __Methodology:__ A pretest-posttest design was used to evaluate critical thinking at the beginning of the program and prior to graduation. The WGCTA was administered to 72 students at two BS Programs. For one of the programs, we had data for multiple classes. The WGCTA is available as an 80 item test with five subsets on inference, recognition of assumptions, deduction, interpretation , and evaluation of arguments. The instrument has established criterion and construct validity ($r=0.55$ to 0.75) and reliability including internal consistency ($r=0.83$), stability of scores over time ($r=0.73$), and correlation between scores of alternate forms ($r=0.73$). Participation in this research study was voluntary as approved by the Internal Review Board at each Institution. Program faculty did not know students' WGCTA Scores and were blinded from the study. Data were analyzed using ANOVA on the differences between pretest and posttest scores with level of significance set at 0.05. Pairwise comparisons were made using Tukey's HSD. __Findings:__ We found a significant improvement in critical thinking for the class of 1996 (CT diff $=9.6 \pm 12$). We found no significant improvement in the pretest (56 ± 8.2) and posttest (53 ± 12.2) scores for the classes from 1993-1995. There were no significant differences in WGCTA scores between groups of students at each program. __Conclusions:__ One conclusion is that the educational changes that we implemented to facilitate problem-based learning (PBL) significantly improved the problem solving aspects of our students' critical thinking. However, we suspect that students may not have taken the test seriously for 1993-1995 since the WGCTA was not a program requirement. In 1996, we stressed more than in the past that students should do their best on the WGCTA. This procedural change may have influenced our results. In order to motivate students in the future, we have modified our research protocol so that the WGCTA is a program requirement, with permission to use the data for research purposes. We believe that this change will improve our ongoing research and increase the validity of our findings to determine if PBL in respiratory therapy can significantly improve critical thinking.

OF-97-085

A COMPARISON OF RESPIRATORY THERAPY STUDENTS' CRITICAL THINKING ABILITIES WITH PERFORMANCE ON THE CLINICAL SIMULATION EXAMINATIONS.

Shelley C. Mishoe, PhD, RRT, Franklin H. Dennison, MEd, RRT, RPFT, Medical College of Georgia, Augusta, GA and Lynda Thomas-Goodfellow MBA, RRT, Georgia State University, Atlanta, GA

__Introduction:__ The purpose of this study was to determine the relationship between students' critical thinking abilities as measured by the Watson-Glaser Critical Thinking Appraisal (WGCTA) with performance on the Clinical Simulation Self Assessment Exams from the National Board for Respiratory Care (NBRC). We also examined performance on these tests with students' grade point average (GPA). The WGCTA has been used in hundreds of research studies and is considered to be the best single measure of critical thinking. The WGCTA assesses the abilities to define the problem, select information for problem solution, recognize stated and unstated assumptioos, formulate or select promising hypotheses, and draw valid conclusions. The Clinical Simulation Exams (CSE) from the NBRC are considered by experts in philosophy\social sciences to be one of the few domain-specific instruments for assessment of critical thinking. __Methodology:__ We administered the WGCTA and the CSE Self-Assessment Form II to 60 students between 1993-1996, prior to graduation from our BS Program in Respiratory Therapy. We compared WGCTA scores with the information gathering (IG) and decision making (DM) scores on the CSE. The WGCTA is available in form A and form B as an 80 item test with five subsets on inference, recognition of assumptions, deduction, interpretation , and evaluation of arguments. The instrument has established criterion and construct validity ($r=0.55$ to 0.75), internal consistency ($r=0.83$), stability of scores over time ($r=0.73$), and correlation between scores of alternate forms ($r=0.73$). Participation in this research study was voluntary as approved by our Internal Review Board. Program faculty did not know students' scores and were blinded from the study. Data were analyzed using repeated measures ANOVA and Correlation Coefficients, with level of significance set at 0.05. __Findings:__ We found a significant correlation ($r=0.34$) between WGCTA (59 ± 7.2) and DM scores (66 ± 15). We also found that GPA ($3.40 \pm .43$) was significantly related to WGCTA ($r=0.45$) and DM ($r=0.43$). These findings are meaningful since we compared data obtained under various testing formats and testing conditions. __Conclusions:__ We conclude that the WGCTA, a valid measure of general CT abilities, relates to GPA and DM. We concur that the CSE measures domain-specific aspects of CT. Students with a higher GPA and greater CT abilities can be expected to perform better on the CSE.

OF-97-084

A COMPARISON OF FACULTY RATINGS OF CRITICAL THINKING AND PROBLEM SOLVING ABILITY TO THE WATSON-GLASER CRITICAL THINKING APPRAISAL AND CLINICAL SIMULATION EXAMINATION SCORES David C. Shelledy, PhD, RRT, Shelley C. Mishoe, PhD, RRT, Robert W. Lawson, MS, RRT and Douglas L. Murphy, PhD. The University of Texas Health Science Center at San Antonio, San Antonio, Texas and Medical College of Georgia, Augusta, Georgia

BACKGROUND Respiratory care educational programs seek to develop student's critical thinking and problem solving abilities. Difficulty in evaluating these skills makes this goal problematic. The Critical Thinking and Problem Solving evaluation instrument (CTPS) is a 21 item assessment tool that allows faculty to systematically evaluate students. Scores generated are totaled and range from 21 (low) to 147 (high) points. The CTPS has evidence of content validity based on review by a panel of experts. The interrater reliability of the CTPS has been reported to be $r = .66$ with Cronbach's alpha of .95-.99. The Watson-Glaser Critical Thinking Appraisal (WG) is designed to measure subjects ability to reason analytically and logically. The WG uses five subtests to assess the ability to make inferences, recognize assumptions, perform deduction, and interpret and evaluate arguments. The scores on these subtests are combined to generate an overall critical thinking score. Form II of the NBRC clinical simulation self-assessment examination (CSE) consists of 7 patient management problems. Performance on these problems is combined to generate an overall information gathering (IG) and decision making (DM) score. We compared faculty ratings of students' critical thinking and problem solving ability using the CTPS to WG, IG and DM scores for graduates at two baccalaureate degree respiratory care programs. **METHOD** Twenty-four respiratory care program graduates were retrospectively evaluated by two faculty from each program using the CTPS. Faculty worked independently and were blinded to students performance on the WG and the NBRC CSE. Interrater reliability coefficients and Chronbach's alpha were calculated as measures of CTPS reliability. Students' CTPS, WG, IG and DM scores at the two schools were compared using the t-test for independent samples. Pearson-product moment correlation coefficients were calculated to compare CTPS scores to WG, IG, and DM. **RESULTS** Interrater reliability for the CTPS was $r = .85$ and $r = .86$ for the two schools, respectively. Cronbach's alpha ranged from .97 to .99. There were no significant differences between students' scores when compared by school for the CTPS ($p = .74$) or WG ($p = .60$). There were significant differences in student performance when compared by school for IG ($p < .001$) and DM ($p < .001$). There was a significant correlation between CTPS scores and WG ($r = .50$, $p = .01$). There was no relationship between CTPS scores and IG ($r = .24$, $p = .27$) or DM ($r = .17$, $p = .42$). There also was no relationship between WG and IG ($r = .09$, $p = .67$) or DM ($r = .12$, $p = .59$). **CONCLUSIONS** There was a significant correlation between faculty ratings of students' critical thinking ability using the CTPS and general critical thinking ability as assessed using the WG. The CTPS and WG were of no value in predicting students performance on the NBRC CSE. More research on assessment of problem solving and critical thinking abilities among respiratory care program students is needed.

OF-97-143

READING LEVELS OF FOUR RESPIRATORY CARE PUBLICATIONS, David W. Chang, EdD, RRT, Columbus State University, Columbus, Georgia

INTRODUCTION: The selection and use of respiratory care journals and magazines by RCP and RC students may be related to the reading level of the respective publications. **METHOD:** The Flesch-Kincaid Readability Index (FKRI) was used to analyze the reading levels of four RC publications. The FKRI was used because it accounts for the average number of words per sentense (WPS) and syllables per word (SPW) in the article. The WPS and SPW are important contributing factors of the readability of written materials such as medical and technical writings. The FKRI is a validated instrument for the assessment of readability when it is used to analyze writing samples of 100 words or more. From each of these four publications printed since December 1996, three articles were selected in random and three paragraphs of at least 100 words were used for the analysis and calculation of the FKRI for each article. The reading level was calculated by using the FKRI formula: Reading Grade Level = (0.39)(WPS) + (11.8)(SPW) - 15.59. **RESULTS:** The FKRI's for the twelve articles analyzed in this study are as follows: *AARC Times* (15, 11, 16), *Advance for RCPs* (16, 14, 12), *Respir Care* (15, 14, 12) and *RT* (14, 15, 15).

Publication (Article #)	(1)	(2)	(3)	Average FKRI
AARC Times	15	11	16	14
Advance for RCPs	16	14	12	14
Respir Care	15	14	12	14
RT	14	15	15	15

CONCLUSIONS: The average reading levels of the four journals seem to be appropriate for RC students. The RC students should not have much difficulty in reading and comprehending the articles in these four RC publications.

OF-97-149

READING LEVELS OF SIX MEDICAL AND ALLIED HEALTH JOURNALS, David W. Chang, EdD, RRT, Columbus State University, Columbus, Georgia

INTRODUCTION: The selection and use of medical and allied health journals by RCP and RC students may be related to the reading level of the journals. **METHOD:** The Flesch-Kincaid Readability Index (FKRI) was used to analyze the reading levels of six journals that publish articles related to respiratory care. The FKRI was used because it accounts for the average number of words per sentense (WPS) and syllables per word (SPW) in the article. The WPS and SPW are important contributing factors of the readability of written materials such as medical and technical writings. The FKRI is a validated instrument for the assessment of readability when it is used to analyze writing samples of 100 words or more. From each of these six journals published since January 1997, three articles were selected in random and paragraph(s) of at least 100 words were used for the analysis and calculation of the FKRI for each article. The reading level was calculated by using the FKRI formula: Reading Grade Level = (0.39)(WPS) + (11.8)(SPW) - 15.59. **RESULTS:** The FKRI's for the 18 articles analyzed in this study are summarized in the table below:

Journal (Article #)	(1)	(2)	(3)	Average FKRI
Am J Respir Crit Care Med	14	14	16	15
Chest	19	17	14	17
Crit Care Med	20	15	15	17
Heart & Lung	14	15	15	15
JAMA	17	15	22	18
Respir Care	15	14	12	14

CONCLUSIONS: The selected journal articles represent an extreme wide range of reading levels (from grade 12 to grade 22). RC educators may want to evaluate the journal articles prior to formulating a plan for student use (e.g., selection of appropriate articles, group discussion, independent reading assignment).

OF-97-159

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AFFECTIVE EVALUATION OF STUDENT CLINICAL PERFORMANCE

Phillip D. Hoberty, EdD, RRT and F. Herbert Douce, MS, RRT, The Ohio State University, Columbus, Ohio. Current accreditation standards require evaluation of student performance in clinical skills and behaviors; however, the specific affective attributes and methods of evaluating them are not delineated. The 1991 Delphi study (DS) of the AARC identified at least 22 affective characteristics, traits, and attributes of the future RC practitioner, but the DS did not identify a minimal frequency at which each attribute needs to be displayed. The purpose of the present study was to determine the minimum expected frequency and to design an evaluation instrument for student affective performance in clinical courses. Method: We designed an questionnaire that listed the 22 attributes and distributed it to 159 educator and manager attendees of the general sessions of the AARC 1996 Summer Forum in Orlando, Florida, and 70 (44%) responded. For each of the 22 attributes, attendees were asked to identify the minimal frequency as "always", "usually", "sometimes" or "rarely" for a satisfactory rating at time of graduation. The results of the survey were used to construct a suitable student evaluation instrument. Results: On 7 attributes a frequency of "always" was required for a satisfactory rating by ≥80% of respondents. The remaining 15 attributes were rated by ≥80% as requiring less than "always." Based on the survey research we constructed a clinical affective evaluation of student performance. The 7 attributes which require "always" as minimal frequency of performance are rated on a "satisfactory/unsatisfactory" (S/U) scale because any performance less frequently observed would be less than satisfactory. The other 15 attributes are rated on an "outstanding / satisfactory / unsatisfactory" (O/S/U) scale because a clear dichotomy in minimal performance was not identified. Points are added to the minimal pass level for each "outstanding" rating in the latter category. Conclusion: Based on a survey of educators and managers, 7 affective attributes were identified as appropriate for a S/U rating scale on clinical evaluation. The other 15 attributes were placed on a O/S/U scale. A rating of outstanding in attributes in this latter group can be used to justify a grade greater than satisfactory in the affective domain.

OF-97-166

RECYCLING LIMIT FOR A DISPOSABLE CAPNOMETER ADAPTER

Robert Messenger BS, RRT Respiratory Care Division - Pulmonary Services Department, MetroHealth Medical Center, Cleveland, OH

Introduction: One of the options available for use with the N-6000 capnometer (Nellcor-Puritan-Bennett, Haywood, CA) is a disposable "single patient use only" mainstream airway adapter (ADAP-UC) We sought to determine the recycling end-point, beyond which the accuracy of data obtained from these adapters would be compromised **Method:** 30 new airway adapters were labeled and numbered Each adapter was evaluated using a calibrated capnometer which was restricted to use only for this study A certified gas (5 07% CO_2), meeting the manufacturer's specifications for sensor verification was passed at 2 lpm through the adapter via a sampling system designed to eliminate contamination with ambient air and the resulting values were recorded After the initial test, all of the adapters were placed into clinical service until either the capnographic waveform dampened or end-tidal monitoring was no longer indicated The adapters were cleaned of gross matter using either a nylon tube brush or cotton tipped swabs Next they were sterilized by soaking in a cold activated gluteraldehyde solution for 30 minutes followed by a 20 minute water rinse and drying in a tube dryer Each adapter was tested again by the previously described method and the results recorded 14 of the original 30 adapters underwent 16 use-sterilization-testing cycles, while 16 adapters were lost or disposed of during the 7 month testing period **Results**: Not until 15 resterilization cycles did any adapter yield a CO_2 value outside of the manufacturers specified range (cycle 15 - 1 failure cycle 16 - 2 failures) Mean adapter calibration values exhibited a progressively increasing trend with each sterilization cycle However when compared using one-way ANOVA, no significant difference was seen between sterilization groups, until 16 cycles were reached (p=0 0409) See table below

Test gas [CO_2]= 5 07%

Test	Initial	1	2	~	8	9	10	11	12	13	14	15	16
n	30	30	30		28	28	28	28	25	20	17	17	14
High	5 3	5 3	5 3	~	5 3	5 3	5 3	5 3	5 3	5 3	5 3	5 4	5 7
Low	4 9	5 0	5 0	~	5 0	5 0	5 0	5 0	5 0	5 0	5 1	5 1	5 1
Mean	3	5 12	5 14	~	5 16	5 15	5 14	5 17	5 18	5 17	5 21	5 19	5 22
SD	0 09	0 10	0 10	~	0 08	0 09	0 10	0 09	0 09	0 07	0 06	0 09	0 15
p		0 8922	0 774	~	0 6545	0 7407	0 827	0 7747	0 5984	0 6086	0 3133	0 1996	0 0409

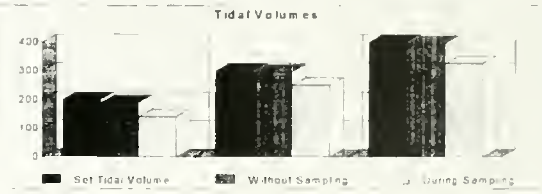
Conclusion Following cold sterilization with activated gluteraldehyde, these disposable adapters can be recycled 15 times without adversely affecting the accuracy of values obtained from their use Further study is needed to determine the effects of other sterilization methods on the durability and accuracy of these adapters

OF-97-017

SIDESTREAM SAMPLING OF NITRIC OXIDE CAN IMPAIR MECHANICAL VENTILATION

Jenni L. Raake, BS, RRT and James Johnson, CRTT
Children's Hospital Medical Center Cincinnati, Ohio

Background: A vital part of delivering Nitric Oxide involves sampling of gases for analyzation of NO and NO_2 levels Analyzing NO and NO_2 is performed by using either sidestream or mainstream sampling techniques Some sidestream analyzers require active gas flow to determine NO and NO_2 levels We set out to determine if sidestream sampling involving active gas flow can impair mechanical ventilation **Methods:** We tested a Siemens Servo 900C (Danvers, MA) with a Biotek VT-1 ventilator tester (Winooski, VT) The ventilator was set at an SIMV rate of 20, an inspiratory time of 1 second, and tidal volumes of 200, 300, and 400cc using a 15 mm circuit (Allegiance Healthcare Corp Round Lake, Il) Nitric Oxide was blended with Nitrogen using a stainless steel blender (Bird Corp , Palm Springs CA) The ventilator air hose was connected to the blender and oxygen hose was connected to clinical oxygen An Ecophysics CLD 700 AL chemiluminescence analyzer (Ann Arbor, MI) was used to monitor NO and NO_2 levels at the inspiratory line of the ventilator circuit Set tidal volumes were compared to tidal volumes measured by the test lung during sampling (active gas flow) and when the analyzer was not being used The tests were repeated three times to insure reliability of results The CLD 700 AL sampling flow rate was measured using a Fischer and Porter (Warminster, PA) flowmeter **Results:** When tidal volumes were set at 200 cc, the test lung measured a tidal volume of 190 cc without sampling, and 140 cc during sampling When tidal volumes were set at 300 cc, the test lung measured a volume of 295 cc without sampling, and a volume of 250 cc during sampling. When tidal volumes were set at 400 cc the test lung measured a tidal volume of 395cc without sampling, and a tidal volume of 325 cc during sampling **Experience:** When NO and NO_2 levels are analyzed, sampling at the inspiratory limb of the ventilator circuit occurs before the set tidal volume is delivered to the patient During active gas flow, sampling removes volume from the ventilator circuit before delivery to the patient The amount of volume removed depends upon the sampling flow rate of the analyzer The CLD 700 AL generates a sampling flow rate of 0 33 lpm Other analyzers may generate more or less vacuum **Conclusions:** Based on the results of the above tests, active sampling can impair mechanical ventilation due to removal of volume from the ventilator circuit As a result, volumes should be adjusted during NO and NO_2 sampling to assure appropriate mechanical ventilation of the patient



OF-97-025

THE EFFECT OF FOURTEEN DAY CIRCUIT CHANGES ON VENTILATOR ASSOCIATED PNEUMONIA.

Mary Turley, RRT, John Votto, DO, Janet Brancifort,BS, RRT, M.Collins, RN, Hospital for Special Care, New Britain, CT.

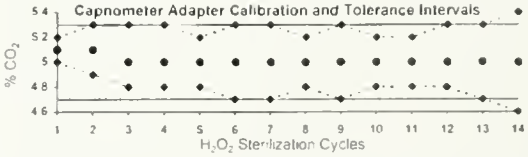
Hospital for Special Care is a 200 bed chronic disease and rehabilitation hospital. With the steady growth of our ventilator dependent patient population and the need to provide quality cost effective patient care we reviewed all areas of our practice for improvement. This study compares the ventilator associated pneumonia (VAP) rates and cost reductions with 7 day vs 14 day circuit changes. METHODS During Phase 1 circuits were changed every 7 days and during Phase 2 circuits were changed every 14 days. Data was collected for 6 months during each phase. Infection Control monitored the occurrence of VAP during this period, using clinical criteria consistent with the CDC. Data was also obtained for ventilator circuit costs and practitioner time spent doing circuit changes. There was no change in mechanical ventilation practice during this time. Heated wire circuits and heat moisture exchange systems were used and patients were on a closed suction catheter system. RESULTS: Based on 8,760 ventilator days (48 patients) in Phase 1 the VAP rate was 1.75/1000 ventilator days. Practioners spent 416 hours doing circuit changes and circuit costs were $25,444 during this time. In Phase 2 there were 10,950 ventilator days (60 patients) and the VAP rate was 1.64/1000 ventilator days. Practioners spent 260 hours doing circuit changes and circuit costs were $18,639. CONCLUSION: Our results would suggest, that in the long term ventilator dependent patient population, ventilator circuits can be changed at 14 day intervals without a significant change in the occurrence of VAP and with a significant savings in circuit costs and practitioner time.

OF-97-026

EFFECT OF HYDROGEN PEROXIDE STERILIZATION ON CAPNOMETER ADAPTER ACCURACY; A BENCH STUDY

Robert Messenger BS, RRT Greg Nichols MSA, RRT, Doug McKay RRT Respiratory Care Division - Pulmonary Services Department, MetroHealth Medical Center
Cleveland, OH

Introduction: Mainstream capnometer adapters frequently become obscured with secretions, necessitating their replacement Although the cost for these adapters is relatively low, the total monitoring cost rises with each new adapter We sought to determine how hydrogen peroxide plasma sterilization of these adapters would effect system accuracy relative to the manufacturer's specifications **Method**: Twenty new disposable mainstream airway adapters (ADAP-UC Nellcor-Puritan-Bennett, Haywood CA) were individually labeled and numbered Each adapter was evaluated using a calibrated capnometer (N-6000, Nellcor-Puritan-Bennett) which was restricted to use only for this study To eliminate errors resulting from variation in ambient pressure, CO_2 measurements were made and expressed on a percentage basis A certified gas (5 0% CO_2), meeting the manufacturer's specifications for sensor verification was passed at 2 lpm through each adapter via a sampling system designed to eliminate contamination with ambient air, and the resulting values were recorded The adapters were then processed by low temperature hydrogen peroxide plasma sterilization Each adapter was tested again by the previously described method and the results recorded Following each testing cycle the tolerance limits (95% confidence) were calculated to ensure that they did not exceed the limits identified by the manufacturer For 13 testing-sterilization cycles the calculated tolerance intervals were within manufacturers specifications **Results**: The calculated tolerance limits were within manufacturer's specifications for the first 13 sterilization-testing cycles Tolerance limits fell outside the acceptable limits on the 14th cycle, representing the end-point of the study Mean adapter calibration values remained relatively stable at each interval of the study



Graph Horizontal solid lines identify tolerance limits identified by the manufacturer Dashed lines represent the upper and lower tolerance limits determined by serial measurements of calibration gas Filled circles indicate mean value of calibration gas measurement

Conclusion Following hydrogen peroxide sterilization, these disposable adapters can be recycled 13 times without adversely affecting the accuracy of values obtained from their use Further study is needed to determine if clinical utilization adversely effects the durability and accuracy of these adapters

OF-97-040

IS STERILE WATER NECESSARY IN WICK TYPE HUMIDIFIERS.

Jim Keenan BS, RRT, John Salyer BS, RRT, Karen Burton RRT, RN Primary Children's Medical Center, Salt Lake City, Utah.

Introduction: We were surprised to learn that the most recent CDC guidelines for infection control recommend the use of.... "sterile, distilled or tap water to fill wick humidifiers" [MMWR 1997;46(RR-1):48]. This could reduce costs of mechanical ventilation by substituting distilled or tap water for more expensive sterile water. Thus we set out to measure microbial growth in ventilator systems using different water types. **Methods** Sterile test lungs were constructed with a built in bacterial filter between the lung and the ventilator circuit. The filters (Nalgene model 130-4045) were rated at 0 45 microns. VIP Bird ventilators, Fisher & Paykel MR 730 wick heated humidifiers, nondisposable Fisher & Paykel MR 340 humidifying chambers, and dual heater wire pediatric size circuits were used. Humidifier temperature setting was 36° C with a chamber control setting of -2. Each circuit/humidifier was assembled as we do clinically, using no extra sterile precautions to mimic clinical conditions. Either sterile, deionoized, tap water, or no water (control) were used in the humidifiers. Two sets of ventilator parameters were used to simulate medium (22 L/m) and high (70 L/m) flow. There were ten samples of each water type tested under medium flow and 6 samples under high flow conditions for a total of 64 samples. Ventilators were operated for ≈ 8 hours after which filters were removed acceptically and placed on agar plates for the standard 48 hour gross growth analyses. **Results:** There was no growth in 95% (61 of 64) samples. Three samples (2 from deionized water, medium flow and 1 from a control sample, high flow) yielded growth as follows; 2 grew coagulase negative unspeciated staphylococcus species, and 1 grew gram positive cocci, two colony types. **Discussion:** Wick humidifiers theoretically produce only water in the gaseous phase. The molecular weight of gaseous water is 18, while the molecular weight of viruses typically range from hundreds of thousands to millions. Thus, gaseous water could clearly not carry pathogens of any type. The growth of organisms we found in a control sample (no water used) leads us to suspect that it may be the result of manual contamination during processing, which may be the cause of the other two positive cultures. Indeed the classification of the organisms grown are consistent with those typically found on human skin. The use of sterile water is an expensive practice, (typical list prices for such water ≈ $4 09/L) and if unnecessary, ought to be eliminated **Speculation:** While these findings are not conclusive, they lead us to suspect that it is safe to use water types other than sterile in wick-type humidifiers, potentially reducing costs. Further study is needed to settle this issue

OF-97-043

SURVEILLANCE OF RESERVOIR CROSS-CONTAMINATION WITH MULTIPLE PATIENT MDI USE

Crystal L. Dunlevy, EdD, RRT, Joseph L Rau, Jr , PhD, RRT, Susan B Roman, MMSc, MT, SM, Georgia State University, Atlanta, GA

Introduction At many hospitals, it is standard practice for RCPs to deliver MDI therapy to patients each patient is supplied with his own reservoir device, and a common canister is used for multiple patients. The purpose of this study was to perform infection control surveillance of MDI canisters for cross-contamination with multiple patient reservoir devices, as they are currently used at a local hospital Materials & Methods Human subjects approval was obtained and data was collected at a 600 bed acute care university teaching institution The Aerosol Cloud Enhancer (ACE) was the reservoir device monitored in the study All patients in the study had been using the ACE for at least 24 hours prior to data collection. All data was collected by the same investigator, using universal precautions. The study population consisted of 60 nonintubated patients who were receiving MDI treatments Three cultures were obtained for each subject The sequence of specimen collection was carried out as follows swab MDI canister nozzle (culture A), disinfect MDI canister nozzle with alcohol prep pad, repeat swab of canister nozzle (culture B), swab ACE MDI adapter site (culture C), administer MDI treatment Specimen collection swabs were inserted into transport packs, labeled, & analyzed by a clinical microbiologist for growth after 1, 2, 3, and 5 days incubation Subjects were profiled according to gender, and age Probabilities for the number of positive cultures will be calculated from a binomial distribution, with a significance level of 0.05. Results 38 subjects were male; 22 were female. Mean age of subjects was 53 For group A, 3 cultures tested positive for Staphylococcus epidermidis; B - 5 cultures tested positive for that same organism, C - 11 cultures tested positive for a variety of organisms Binomial distributions for each culture set (A, B, and C) were < 0 001, indicating significantly low probability of obtaining a positive culture. Conclusion The likelihood of contamination is low when common canisters are used with multiple reservoir devices Because canisters may be shared without significant risk of contamination, this may translate into savings for both patient and respiratory care department

OF-97-126

THE PRACTICE OF HANDWASHING AND USING GLOVES CAN BE IMPROVED AMONG RESPIRATORY CARE PRACTITIONERS (RCP) IN THE INTENSIVE CARE UNIT (ICU).

Mohamad Khatib[1], Afif Ahdailah , Youssel Ibrahim , and Ghassan Jamaleddine American University of Beirut, [1]Dept of Anesthesiology and [2]Medicine, Beirut, Lebanon.

INTRODUCTION: Health care providers are primary pathways for transmission of pathogens among patients in hospitals Appropriate handwashing techniques and the use of protective aids (e g., gloves and masks) are necessary to improve infection control Unfortunately these techniques and tools are either not practiced appropriately or forgotten by the caregivers The purpose of this study is to evaluate the effectiveness of warning labels permanently attached to the ventilators in improving handwashing and use of gloves by RCPs in the ICU **METHODS:** The study consisted of two four weeks periods Daily observations of handwashing and use of gloves by RCPs were made over four one hour observation periods (two on day shift and two on evening shift). Prior to the first 4 weeks period, in-service lectures on handwashing techniques and use of gloves were given to all shifts. At the end of the first period, "WASH HANDS & USE GLOVES" labels were permanently placed on all ventilators RCPs were not aware they were being observed for handwashing and use of gloves in either period The Wilcoxon rank sum test was used for statistical analysis **RESULTS:** Data are presented in Tables 1 & 2 for the two periods

A # Handwash before encounter	C Wear gloves before encounter
B # Handwash after encounter	D Take off gloves after encounter

Table 1. First 4 weeks period (no labels)

	# of encounters	Handwashing		Gloves	
		A (%)	B (%)	C (%)	D (%)
1st Week	142	111 (78%)	131 (92%)	79 (56%)	79 (100%)
2nd Week	129	62 (48%)	99 (77%)	48 (37%)	48 (100%)
3rd Week	134	36 (27%)	114 (85%)	43 (32%)	43 (100%)
4th Week	132	38 (29%)	103 (78%)	59 (45%)	59 (100%)
Total	537	247 (46%)	447 (83%)	229 (43%)	229 (100%)

Table 2: Second 4 weeks period (with labels) * p <0 05 vs Table 1

		A (%)	B (%)	C (%)	D (%)
1st Week	149	140 (94%)*	140 (94%)	140 (94%)*	140 (100%)
2nd Week	143	126 (88%)*	129 (90%)*	126 (88%)*	126 (100%)
3rd Week	127	121 (95%)*	121 (95%)*	121 (95%)*	121 (100%)
4th Week	124	115 (92%)*	115 (92%)*	115 (92%)*	115 (100%)
Total	543	502 (92%)*	505 (93%)	502 (92%)*	502 (100%)

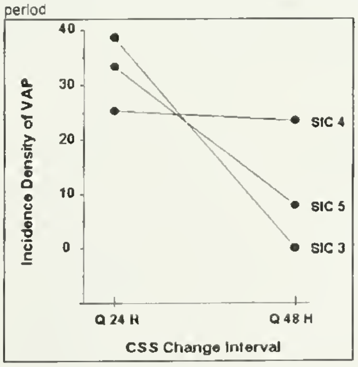
Rates of handwashing and use of gloves were significantly higher during the second period when labels were attached to the ventilators. During the first period the rates of handwashing and use of gloves were declining over time which was not observed during the second period **CONCLUSION:** Simple measures such as placement of reminding labels on mechanical ventilators can significantly improve handwashing and use of gloves practice by RCPs in the ICU This should help in minimizing and limiting the transmission of pathogens via health caregivers and thus improve infection control in hospitals

OF-97-140

CLOSED SYSTEM SUCTION CATHETERS: THE EFFECT OF DECREASED FREQUENCY OF CHANGES IN MECHANICALLY-VENTILATED PATIENTS.

Subasree Srinivasan MD, Francina Singh RN MPH CIC, Margaret Wojnar MD, Michael McPeck BS RRT, William Greene MD Departments of Health Care Epidemiology / Quality Management and Respiratory Care University Medical Center, State University of New York at Stony Brook

BACKGROUND: Closed system suction (CSS) catheters, which have been in use in our intensive care units, were being changed at 24 h intervals in accord with the manufacturer's recommendations Because our ongoing surveillance has determined that ventilator circuit change intervals of 168 h (7 days) has not been associated with adverse outcomes, we proposed changing CSS catheters at 48 h intervals while measuring outcomes **PURPOSE OF STUDY:** To compare incidence densities (ID) of ventilator associated pneumonias (VAP) per 1,000 ventilator days with CSS catheter-related problems (if any) between time periods of CSS catheter change intervals of 24 and 48 h **METHODS:** We conducted prospective data collection and analysis on all patients admitted to the Surgical ICU who required mechanical ventilation ≥72 h. Two time periods and two CSS catheter change intervals were analyzed Period 1 ran from 4/1/96 - 6/30/96 during which CSS catheters were changed at 48 h intervals Period 2 ran from 7/1/96 - 9/30/96 during which CSS catheters were changed at 24 h intervals Data collection included ID of VAPs, Severity of Illness Scores (SIC) plus reports of any events that necessitated change of CSS catheter prior to scheduled date **RESULTS:** (1) There were 98 admissions requiring ≥72 h of mechanical ventilation and the SICs were distributed thusly 12 2% of patients were SIC 3, 65 5% were SIC 4 and 22 3% were SIC 5 (2) Results (figure) were stratified based on the SIC scores for each period



CONCLUSION: This data from this preliminary study supports the prediction that CSS catheters in our hospital can be safely changed at 48 h intervals without adverse outcomes Savings in direct costs and labor are advantages Based on our 1995 actual purchase data, we project direct cost savings of ~$25,000 per year by changing clinical practice such that CSS catheters are changed at 48 h intervals rather than 24 h The study continues in the Medical and Surgical intensive care units

Presented at The Society for Healthcare Epidemiology of America. April 27, 1997

OF-97-147

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BRONCHOPULMONARY HYGIENE PHYSICAL THERAPY AND CHRONIC AIRWAYS DISEASE. A SYSTEMATIC REVIEW Arthur Jones, EdD, RRT, Brian Rowe, MD **Question:** What are the therapeutic effects of bronchopulmonary hygiene physical therapy (BHPT) on patients with chronic airways obstruction? **Methods:** We used the following terms to search the Cochrane Airways Group database. Postural drainage OR physical therapy OR percussion OR physiotherapy. This database includes trials involving asthma, bronchiectasis, bronchiolitis, COPD, sleep apnea and wheezing. It is a composite of the MEDLINE database from 1966 to 1995, Embase from 1980 to 1995, and CINAHL from 1982 to 1995. Besides the computer search, we examined reference lists of trials and reviews for additional trials. Also, we queried primary authors of trials on the existence of other trials. Two reviewers applied inclusion/exclusion criteria to potential trials and assessed the methodological quality of the RCTs. We used Cochrane's system for categorizing allocation concealment and a modified version of Jadad's 5 point scale for quality assessment. Weighted kappa (Kw) and simple agreement (SA) measured agreement between evaluators. Consensus was reached via email dialogue. Data were extracted by one reviewer, then verified by the other. We used Cochrane Review Manager, Windows version 2.1a, to compile and analyze the data. As the dependent variables were continuous, weighted mean differences with 95% confidence intervals measured effects. **Results** The initial search identified 95 potential trials. Four more were identified from reference lists. Application of inclusion/exclusion criteria left 10 trials to review. The Kw and SA for allocation concealment and trial quality were (1.0, 1.0) and (0.1, 0.25), respectively. The mean quality score was 1.4 (5 = highest). Within the 10 included trials, there were 13 separate comparisons-of-interest, that addressed 11 different dependent variables. The trials were incommensurable for statistical aggregation because trials that addressed similar interventions used disparate dependent variables. Therefore, we computed neither composite effect magnitude nor measures of homogeneity. Since the studies could not be aggregated, the sensitivity analysis for quality and effects could not be done. Notably, there was only one trial that scored 3 out of a possible 5 on the quality scale. This was the second largest trial (N=33) and found no significant effects. The predominant significant effects favor BHPT for clearance of sputum and radioaerosol particles from the lung. But, there was no evidence that lung function was improved by BHPT. These results are based on a total of 153 patients. Studies with positive results involved at total of 67 patients. **Conclusions:** Given the size and quality of the trials, the research on BHPT is confused. Therefore, we cannot support the routine application of BHPT to patients with chronic airways obstruction. There is an apparent need to conduct adequately-sized RCTs that examine the effects of BHPT on clinical outcomes related to mortality and morbidity.

OF-97-003

EVALUATION OF AN OXYGEN CONSERVING DEVICE WITH EXERCISE IN PULMONARY REHABILITATION

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BACKGROUND: We evaluated the ability of an oxygen conserving device (OCD) to maintain oxygen saturation levels similar to continuous flow oxygen (CFO) in patients with Chronic Obstructive Pulmonary Disease (COPD) requiring supplemental oxygen with exercise. The OCD, developed by Western Medica, Inc., utilizes a microprocessor to continuously interact with the patient's ventilation and deliver oxygen through a nasal cannula for a percentage of the inspiration only. Inspiratory percentages can be set by the Respiratory Care Practitioner. The unit re-evaluates the inspiratory time every breath to continually readjust the length of the delivered inspiration. The amount of oxygen delivered will depend upon the set liter flow, respiratory rate, and inspiratory time percentage. METHOD. The sample population consisted of 12 participants diagnosed with COPD and actively enrolled in a Pulmonary Rehabilitation program. Each individual was currently using oxygen between 2 and 4 liters per minute with exercise. This was a blind test with the first day of exercise evaluated using CFO, the second day with the OCD. Three OCD's were set to deliver oxygen for 61.8% of inspiration. One unit was set to deliver oxygen for 40% of inspiration. The OCD units were color coded, but the therapists administering the tests were unaware of which unit was set at 40%. Data was collected at rest, 3 minutes, and 7 minutes of exercise on each of 3 pieces of equipment. The exercise equipment used included an airdyne bicycle, treadmill, and graded armcrank. Exercise prescriptions with metabolic levels were determined by the rehabilitation coordinators and the supervising Pulmonologist. Participants were monitored for changes in Sp02 and Heart Rate (HR). Results were evaluated using a paired t-test, a p-value of .05 was considered significant. Mean values for HR and Sp02 were calculated for both methods of oxygen delivery, on each piece of equipment, at rest and with exercise. RESULTS: No statistical significance was found between the 2 methods of oxygen delivery. All of the OCD's were able to deliver oxygen in quantities sufficient to maintain values similar to those achieved with CFO. The OCD's continued to trigger at respiratory rates up to 44/minute. Participants were interviewed after completing the study. They reported little or no difference between the 2 methods of oxygen delivery. One participant noted that the cannula was heavy and uncomfortable.
CONCLUSIONS. Our results indicate than an OCD developed by Western Medica, Inc., can be utilized by patients with COPD requiring oxygen during exercise. The OCD can be set to deliver oxygen when it will participate in gas exchange and can be attached to any oxygen delivery system. It can be used at rest as well as with exercise. The amount of oxygen saved will depend upon the liter flow, respiratory rate, and the subjects inspiratory time. For the ambulatory patient this oxygen conservation should allow increased time away from a stationary cylinder and reduce the amount of oxygen used each month.

OF-97-023

CLINICAL RESEARCH "LMG" PROTOCOL FOR WEANING FROM MECHANICAL VENTILATION IN CHILDREN WITH NEUROMUSCULAR PATHOLOGY Luisa Maria Giorgetti PT, Claudia Rossello PT, Gustavo Olguin PT. Garrahan Pediatric Hospital, Physical Therapist Department. Buenos Aires, Argentina.

We have established a clinical research protocol (LMG) to systematize the weaning from mechanical ventilation of children with reversible and/or irreversible neuromuscular pathology. A retrospective analysis of 83 cases (1979-1988) revealed discordancy in (1) basic clinical/physiologic condition at the outset of weaning, (2) manner of evaluating respiratory mechanical effectiveness (DRME), (3) plan for training for weaning. Material & Methods. We decided to train the skeletal muscles. Criteria for entry into weaning training were (1) no acute pulmonary pathology for minimum of 48 h, stable MV PaO2 ≥ 60 mm Hg, PaCO2 ≤ 45 mm Hg, and SaO2 ≥ 95%. The score for DRME was derived from respiratory muscle assessment (RMA), RR, HR, and cough, problems with swallowing, and level of cooperation (incidents), rated from 4 to 0 points or good to non-existent. The sum of the individual values yields a score that reflects the sufficiency of the patient's respiratory mechanics, with 9-13 being Good, 4.5-8.5 Regular, 2-4 Poor, and 0-1.5 Vestige/Disappeared (or non-existent. Our plan for active training of respiratory muscles to fatigue is based on principle that affirms repetition of movements to 75% of the maximum sustainable load (ML), alternating with periods of rest, leads to progressive strengthening of weak muscles. Therefore, we replaced ML with a time limit for voluntary repetition (LT) without meaningful changes in RR and HR, that is working time (WT). The weaning training would consist of 3 periods in WT of voluntary respiration with or without supplemental oxygen according to need, alternated with periods of rest distributed over 12 hours daily on 2 successive days respecting nocturnal MV. New LT and WT would be determined every 2 days,with the times of work and rest programmed until the patient is capable of 12 hours of voluntary respiration for 2 days and would then be considered weaned. Conclusion: we believe that the protocol allows us to quantify respiratory muscle effectiveness, plan a training program, and predict the time required for weaning.

OF-97-030

APPLICATION OF THE CLINICAL RESEARCH "LMG" PROTOCOL IN WEANING FROM MECHANICAL VENTILATION(MV)IN CHILDREN WITH GUILLAIN-BARRÉ SYNDROME (GBS) Gustavo Olguin PT, Claudia Rossello PT, Luisa Maria Giorgetti PT. Garrahan Pediatric Hospital, Physical Therapist Department. Buenos Aires, Argentina
We sought to validate a clinical research protocol (LMG) that (1) establishes the basic clinical and physiologic criteria for entering neuromuscular patients into a program of training for weaning, (2) incorporates a score for effectiveness of respiratory mechanics, and (3) provides a program of active training to overcome muscle weakness. Materials & Methods. From 1989-1998 14 patients with GBS were treated in our ICU—8 with acute demyelinating neuropathy (ADN) and 6 with motor or axonal neuropathy-like variants. Patients ranged in age from 10 months to 15 years, 6 girls and 8 boys. All required mechanical ventilation (MV)—12 for progressive ventilatory incapacity and 2 for acute respiratory pathology. Criteria for entry into weaning training were (1) no acute pulmonary pathology for minimum of 48 h; stable MV PaO2 ≥ 60 mm Hg, PaCO2 ≤ 45 mm Hg, and SaO2 ≥ 95%. Respiratory mechanical effectiveness (DRME) was determined from our Clinical Score, with 9-13 being Good, 4.5-8.5 Regular; 2-4 Poor, and 0-1.5 Vestige/Disappeared. The weaning plan was initiated on patients whose score was ≥ 4.5 and with supplemental oxygen if required. Limit time (LT) was determined and from LT Working Time (WT, or time off of MV, equivalent to 75% of LT). Training schedule consists of 3 periods of disconnection (WT) alternating with periods of rest on MV. Every 2 days DRME was reexamined and a new LT-WT determined, reflecting progress in training weakened muscles. After 2 daily disconnections of 5 h, the next step was disconnection for 12 hours for 2 days, and then permanent disconnection with extubation. Results. Weaning was possible with scores ≥ 6. Weaning initiated with scores between 6 and 11 and no acute respiratory complications lead to achieving weaning in 100% of patients between Day 2 and Day 16 with a mean of 8 days. Commentary. Protocol implementation permits us to predict a mean weaning time of 8 days. The cost/benefit relation is important. We are convinced that this Protocol can be successful and is economical and could be applied to other respiratory pathologies that require lengthy MV.

OF-97-031

ASSESSMENT OF OXYGEN SATURATION WITH EAR VS FINGER OXIMETRY IN PATIENTS WITH CYSTIC FIBROSIS

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Ear or finger oximetry measurements are often utilized in patients with cystic fibrosis (CF) We have previously reported that oximetry values obtained from the ear may be significantly higher than from the finger and that the amount of difference between the two is more closely associated with deterioration in pulmonary function (rho= 0 259, p<0 01) and decreased oxygenation (rho=0 876, p<0 001) rather than the magnitude of clubbing (rho=0 164, p=ns) (1). In order to determine which measurement site more closely reflects "true" oxygen saturation, we simultaneously obtained 11 arterial blood gas samples (ABGs) and oximetry readings in 9 patients with CF on 11 different occasions All patients had at least a 4% difference in ear vs finger readings Oximetry on the ear and finger was measured with the Ohmeda 3700 oximeter and arterial blood was analyzed with a Radiometer (ABL 500 or 520), all are accurate within 2% of the reading. The measurements of pO2 and sO2 were comparable for either the ABL 500 or 520 The mean (range) of SaO2 by ABG was 91 7 (88.7-95.6%), by ear was 94 0 (90-98%), and by finger was 89 7 (86-93%) All three mean values were significantly different from each other (paired t ≥ 3.86, p≤0 002). Although finger oximetry readings more closely correlated with oxygen saturation obtained by ABG (r=0 77, p=0 005) than ear oximetry (r=0 63, p=0 039), the mean finger and ear correlated the best (r=0 84, p=0 001). We conclude that 1) Neither ear nor finger oximetry readings accurately reflect "true" arterial oxygen saturation as obtained by ABGs as ear readings tend to overestimate the "true" value and finger readings, although closer, tend to slightly underestimate the value. 2) The average of the two site values most closely approximate "true" arterial saturation 3) Inaccurate measurement of arterial saturation may lead to erroneous estimation of a patient's need for oxygen supplementation

1 Strizek S, Hordvik N, Hallberg T, Colombo J Comparison of ear vs. finger probes in cystic fibrosis (CF) Respir Care, 40(11) 1165, 1995

OF-97-033

CHANGES IN OXYGEN SATURATION AND OXYGEN USE FOLLOWING PROGRESSIVE STEP PULMONARY REHABILITATION.

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A retrospective study was performed on the first six patients post completion of The Progressive Step Pulmonary Program at The Institute For Health and Healing in Jacksonville Florida The patients ranged in age from 44 to 76 with a mean age of 65 All six patients were female and suffered from a variety of breathing disorders Chronic Obstructive Pulmonary Disease (4) Emphysema (1) and Bronchiectasis (1) Four of the six patients used oxygen therapy on a continuous basis 24 hours a day One of the patients used oxygen on an intermittent basis and at night Each patient's oxygen saturation (SpO2) was measured via an Ohmeda 3760 pulseoximeter before, during and after therapy Each patient attended the program three times a week for no more than eight weeks. The patients were seen on an individual basis and not in a group A multi-team approach was used and included Respiratory Therapy, Occupational Therapy, Social Services and Physical Therapy Patients were rotated through each therapy based on their Respiratory Score (R.S) The R.S is determined by the results of the patient's forced vital capacity at one second FEV1%, perceived dyspnea score (PDS) and the distance the patient is able to walk before becoming short of breath Oxygen saturation (SpO2) increased in all six patients ranging from (3 1) % to (16.0) % with a mean increase of (9 25) % S D (2 9) Range (12.9)% As a result of oxygen saturation (SpO2) improvement, four of the five patients who were on a regimen of oxygen therapy were taken off One patient remained on oxygen therapy on an as-needed basis only Dyspnea is caused by a multitude of factors including hypoxemia and the inappropriate use of breathing muscles The Progressive Step Pulmonary Rehabilitation Program applies an individualized treatment program for each patient which concentrates on the mechanisms of dyspnea for that patient. This approach allows for aggressive treatment for the individual and allows the patient to regain physical strength and decrease the work of breathing Further studies are warranted

OF-97-074

WORKLOAD MEASUREMENTS OF 5 DIFFERENT NONINVASIVE PRESSURE-TARGETED VENTILATORS DURING VARIOUS LEVELS OF INSPIRATORY DEMAND AND OXYGEN TITRATION A BENCH TEST STUDY Michael D. Coutts, RRT, Kelly Jager, RRT, Martin Tweedale, MB,PhD Vancouver Hospital & Health Science Centre, Vancouver, British Columbia, Canada

Introduction: The number of noninvasive pressure-targeted ventilators being developed have increased dramatically over the past few years The purpose of this study is to compare 5 different models of pressure-targeted ventilators (PTVs) when different levels of inspiratory demand and different levels of titrated oxygen flow are applied **Methods** A two chambered lung model was used with one side attached to the PTV and the other side attached to a ventilator (PB 7200ae), which simulated the patient efforts A leak was maintained in the NIV circuit using a Respironics whisper swivel Two PTVs of each model were tested (STD 30 BiPAP, PB 335, PB 320b, Quantum, and VPAP) and three consecutive breaths were recorded for each test Each test was done at flowrates of 30, 60, 90, and 120 L/min and at oxygen flowrates of 5, 10, 15 L/min, and flush All PTVs were tested at IPAP of 10 cmH$_2$O and EPAP of 4 cmH$_2$O The response time (Tr), rise time, and maximum negative pressure (Pneg) was determined Statistical analysis was done by ANOVA with differences considered significant when p≤ 0 05 **Results** Significant differences between all PTVs were noted throughout all testing levels During testing of oxygen titration the Quantum had a Tr that was slower and had a Pneg that was more negative than the other PTVs, the rise times were consistent throughout all machines During testing of the different flowrates the results varied between the different PTV At a ventilator flowrate of 60L/min the PB 335 and PB 320b achieved the fastest rise time The STD 30, PB 335 and VPAP had the best Tr The Std 30, PB 320b and VPAP obtained the lowest Pneg Mean values at a ventilator flowrate of 60 l/min are listed below

	Quantum	STD 30	PB 335	PB 320b	VPAP
Rise Time (s)	35 ± 0 04	40 ± 0 10	.20 ± 0 05•	29 ± 0 04	54 ± 0 01
Tr (s)	.42 ± 0 03	12 ± 0 02★	18 ± 0 02★	.26 ± 0 26	14 ± 0 02★
Pneg (cmH$_2$O)	-1 76 ± 0 46#	- 66 ± 0 25	-1.08 ± 0 10◻	- 81 ± 0 27	-.44 ± 0 06

• p ≤ 0 01 PB 335 significantly lower rise time vs Quantum, VPAP, STD 30
★ p ≤ 0 01 STD 30, PB 335, VPAP significantly lower Tr vs Quantum, PB 320b
# p ≤ 0.01 Quantum significantly higher Pneg vs STD 30, PB 335, PB 320b, VPAP
◻ p ≤ 0 01 PB 335 significantly higher Pneg vs VPAP

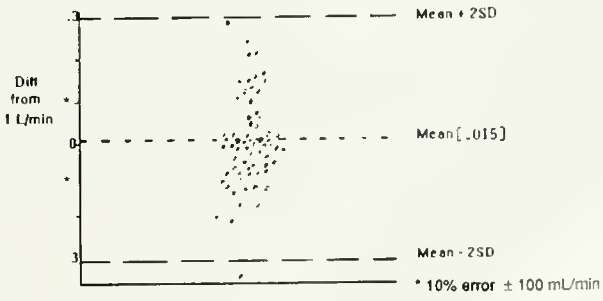
Conclusions: As the data indicates there are differences between all the PTV Each PTV achieved optimal values in one or more of the measured parameters Therefore it is difficult to make a clear decision as to which PTV performs optimally in all testing situations. This data was obtained from a bench test perspective therefore, to make a definitive decision on a specific bilevel unit further studies should be performed within the clinical setting

OF-97-034

0-16 L/MIN OXYGEN FLOWMETERS ARE NOT ACCURATE IN DELIVERING LOW-FLOW THERAPY. Boynton B CRTT, Jung S RRT, Nelson S RRT, Potts C. CRTT, Rankin D. CRTT, Reed M. CRTT, Salzwedel K. RRT, Schuelke D CRTT, Stewart T. CRTT, Weathers P. CRTT, Ward J RRT, Helmholz H., Jr. MD, Plevak D. MD. Rochester Community College and Mayo Foundation, Rochester, MN

Background: Some patients with chronic obstructive pulmonary disease (COPD) require accurate administration of low flow oxygen. For proper patient care, we felt that oxygen flowmeters should be accurate to within 10% error at flows ranging from 1-3 L/min. We performed this investigation to see if there was sufficient agreement between the settings on 0-16 L/min oxygen flowmeters and measurements made by a calibration analyzer. **Methods:** Oxygen flow measurements were made by a Timeter RT 200 Calibration Analyzer (Allied Healthcare Products Inc., St. Louis, MO) The accuracy of the analyzer was confirmed using a Tissot water-sealed spirometer. Following a pilot study accomplished to determine the number of flowmeters needed for sufficient statistical power, a random selection of 74 Ohio/Ohmeda oxygen flowmeters currently in clinical use were tested at three flows: 1, 2, and 3 L/min Flow settings were made visually and verified by three observers; the center of the indicator ball was used as the landmark. The oxygen flow analyzer measurement was recorded after the reading had stabilized. Bland-Altman plots were used to analyze the data. Statistical agreement between the oxygen flowmeter settings and the analyzer measurements would have been confirmed if 95% of the data points (two standard deviations) were contained within a 10% margin of error for each flow level. **Results:** The standard deviation of data points at 1 L/min was 0.15 (see Fig. 1), at 2 L/min was 0.18 and 3 L/min 0.31. Standard deviations of data exceeded the 10% margin of error in all three flow settings. **Conclusion:** 0-16 oxygen flowmeters are not accurate at flows from 1 to 3 L/min and should be used with caution in patients with COPD.

Fig. 1



OF-97-075

COMPARISON OF IMPOSED WORK THROUGH TRACHEOSTOMY SPEAKING VALVES AND TRACHEOSTOMY TUBES USING A SPONTANEOUS BREATHING MODEL

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INTRODUCTION Tracheostomy speaking valves (TSV) are commonly used in patients with a tracheostomy TSV are employed to enhance communication, decrease aspiration and improve swallowing mechanics. Knowledge of relative imposed work of breathing (WOBi) through TSV and tracheostomy tubes could guide clinicians in choosing the appropriate combination of TSV and tracheostomy tubes In order to obtain this information we measured WOBi through five commercially available TSV and three different diameter tracheostomy tubes. **Method** The five TSV studied were Montgomery (M), Passey-Muir (P), Instrumentation Industries (I), Olympic (O) and Shiley (S) Three different diameter Shiley tracheostomy tubes (6mm, 7mm, 8mm ID) were also studied. A Bio-Tek VT 1 test lung was modified to simulate spontaneous breathing in a sine wave pattern at Vts of 300, 500 and 700 ml respectively IE ratio was held constant at 1 4 (flow range 32-75 L/min at a RR of 15/min) WOBi was measured using a Novametrix VenTrak 1550 respiratory mechanics monitor In random fashion three valves from each manufacturer and one tracheostomy tubes of each diameter were tested WOBi is the average of 10 breaths through each device minus baseline work (no valve or tube in line) The Anova Single Factor Test was performed on all devices at each Vt **Results**

Vt	Valves					Trach Tubes (ID)		
	M	P	I	O	S	6 mm	7 mm	8 mm
700 ml								
WOBi (joules/L)	0 306	0 401	0 604	0 519	0 423	0 828	0 524	0 335
SD±	0 007	0 015	0 006	0 027	0 015	0 003	0 003	0 003
	p < 0 001 all valves Vt 700 ml					p < 0 001 all trach tubes Vt 700 ml		
500 ml								
WOBi (joules/L)	0 205	0 269	0 443	0 279	0 271	0 560	0 327	0 225
SD±	0 010	0 010	0 024	0 021	0 014	0 003	0 003	0 002
	p < 0 001 all valves Vt 500 ml					p < 0 001 all trach tubes Vt 500 ml		
300 ml								
WOBi (joules/L)	0 151	0 168	0 283	0 117	0 159	0 242	0 143	0 095
SD±	0 003	0 005	0 005	0 014	0 003	0 002	0 001	0 002
	p < 0 001 all valves Vt 300 ml					p < 0 001 all trach tubes Vt 300 ml		

Conclusions: 1.) Under these study conditions, there are statistically significant differences in WOBi between all TSV and tracheostomy tubes; however all valves would be clinically acceptable for spontaneous breathing 2) Because WOBi through a TSV and tracheostomy tubes is additive, a combination of a higher work valve (I or O) and a smaller diameter tracheostomy tubes could produce unacceptable levels of work, especially in patients with minimal pulmonary reserve

OF-97-102

LUNG VOLUME REDUCTION -OBJECTIVE AND SUBJECTIVE EVALUATION

BY Deborah J. Hughes, BS, R.R.T.,C.P.F.T., University of Rochester Medical Center, Rochester, N Y

Advances in technology and surgical techniques have caused a renewed interest in lung volume reduction (LVR) for the treatment of severe emphysema. Data from the LVR Registry and the Society of Thoracic Surgeons has been encouraging, citing improvements in pulmonary function, exercise endurance, and subjective symptoms. A retrospective study provided a means to evaluate the benefits of this procedure. Preoperative selection criteria included disabling emphysema unrelieved by medical therapy; severe hyperinflation as evidenced by CXR and CT scan, and FeV1< 35% predicted. Data from 20 patients was obtained preoperatively and at 3 and 6 months postoperatively. Those excluded from the study were 1 death, 1 ventilator dependent, 2 former laser procedures, 1 Alpha 1-antitrypsin, and 3 due to noncompliance with follow up Preoperative and 6 month assessments were compared for the remaining 12. Objective data showed improvement in pulmonary function. Mean spirometry values revealed the following changes: FVC 2.39L ±.80 to 2 80L ± 84, $p= 022$; FeV1 .658L± 21 to 873L ±.380, $p=.014$; TLC 8.80L±1.91 to 7 21L ±1 94, $p= 000$ and RV 6 13L±1 40 to 4 34L±1.43, $p= 000$. Endurance assessed per the 6 minute walk increased from a mean of 718 feet ±335 to 907 feet ±411, $p=0.58$. Subjective evaluation was accomplished by the use of dyspnea scales including the Modified Medical Research Scale(MRC) and Baseliene\Transition Dyspena Indices (BDI). The mean MRC score was 3 0±1 0 preoperatively, corresponding to: "Stops for breath after walking 100 yards or a few minutes on the level, breathless with daily activities." The mean score at 6 months was 1.5 ±1 12, corresponding to: "Troubled by S.O.B. when hurrying on the level or walking up a slight hill. "The mean BDI for function preoperatively was .58 ±1.24 corresponding to "Severe to very severe impairment, unable to work or has given up almost all activities due to S.O.B " Mean score at 6 months was increased by 1.0 ±.95 grades indicating: "Minor improvement, able to return to work at a reduced pace or has resumed some activities with more vigor " The mean BDI for magnitude of task preoperatively was 1 08 ±.79, corresponding to "Becomes S O B. with light activities walking on the level, washing, or standing." Mean score at 6months increased by 1.92 ±.67 grades indicating: "Moderate improvement, becomes S.O.B. with moderate tasks such as walking up a gradual hill or carrying a light load on the level." The mean BDI for magnitude of effort preoperatively was 1 25 ± 62 corresponding to "Becomes S.O B. with little effort, tasks often performed with frequent pauses." Mean score at 6 months increased by 1.00 ±1.41 grades indicating "Minor improvements, able to do things of greater effort with out S O.B.." Conclusion LVR offers emphysema patients improved quality of life through increased functional ability and decreased feelings of dyspnea.

OF-97-108

BEHAVIORAL OUTCOMES FOLLOWING USE OF NONINVASIVE POSITIVE PRESSURE VENTILATION (NPPV) IN STABLE HYPERCAPNEIC PATIENTS

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Introduction: The use of NPPV to delay intubation in the acute care setting has been well-researched Its use in patients suffering from chronic ventilatory failure, however, has not been well-documented in the medical literature The purpose of this study was to assess behavioral outcomes of patients suffering from chronic ventilatory failure who were prescribed NPPV for home use **Materials & Methods:** 88 patients from 6 home care company locations with a diagnosis of COPD completed a 31-item questionnaire designed to evaluate the effect of NPPV on ADLs and severity of symptoms Information was collected on sleep patterns, both before and after treatment with NPPV Incidence of complications associated with NPPV was also obtained Means and percentages were calculated for each measure **Results:** 49 males and 39 females participated in the study Subjects reported that they slept an average of 27% longer, woke up 51% less often, and took 34% fewer daytime naps after an average treatment time of 1 7 months with NPPV Greater than 50% of patients reported improvement in their ability to perform 7/8 ADLs, and 4/7 quality of life indicators 93% reported improved quality of sleep, 81% reported improved energy levels, 92% reported improved ability to walk on a flat surface Only 1 patient reported any worsening of symptoms following use of NPPV A minority of patients reported minor complications associated with NPPV, most frequently, nasal dryness and congestion **Discussion:** The stable hypercapneic patients who responded to this questionnaire reported a high degree of improvement in their ability to function daily, as a result of their treatment with NPPV Many of these improvements may be the result of improved sleep patterns, as further evidenced by the anecdotal remarks made by respondents While more studies need to be completed, the data obtained from this pilot study suggests that NPPV may improve the quality of life and the ability to perform ADLs in patients suffering from chronic ventilatory failure

OF-97-125

AN INCREASE IN THE NUMBER OF VENTILATOR DEPENDENT INDIVIDUALS (VDI) IN MINNESOTA FROM 1992-1997.

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Background: No registry of VDIs in the United States currently exists. In 1986 and 1992 we conducted complete surveys of VDI care providers in Minnesota and reported an increase in VDIs of 110% between those years. Since 1992 there has been a clarification of the role for non-invasive ventilation and, we suspected, an increase in its use with VDIs. There has also been an increase in facilities providing care for ventilated patients, including 2 group homes specifically for VDIs. **Methods:** We repeated our survey in 1997 in an identical manner to the previous surveys (Chest 1993; 103.1463). We contacted all known care providers for VDIs in Minnesota and requested information (without personal identifiers) about the VDI. A VDI is defined as requiring ventilatory assistance for more than 6 hr/day for more than 30 days. The definition includes patients receiving non-invasive ventilation with bilevel pressure devices using a back up rate. Our methods may not report those that own their device and do not receive service. We will, also, not report patients that receive bilevel positive pressure ventilation without a back up rate but who may be, in fact, ventilator dependent **Results:** By our methods, there was a 35% increase in VDIs between 1992 and 1997 48% of that increase was attributable to VDIs receiving non-invasive ventilation. VDIs receiving non-invasive ventilation were in each diagnostic category, without a predominating specific disease. The percentage increase (35% compared to 110%) and VDI added/year (14 2 compared to 19.0) has lessened between the 1992 and 1997 surveys The percentage of VDIs receiving care in facilities, compared to care at home, continues to increase to over 40% of the total in 1997. **Conclusions:** The rate of increase in VDIs appears to be decreasing compared to the 1992 survey. Since the 1992 survey there is an increase in the use of non-invasive ventilation. The increase in the use of non-invasive ventilation and the increase in use of care facilities for VDI care are less expensive options than acute care or home care with full time licensed care providers. The decreasing rate, increased use of non-invasive ventilation and choice of care facilities may be explained, in part, by a general effort to control costs. Future surveys or studies of VDIs would be aided by a more refined definition of ventilator dependency. Supported by SCOR HL50512 and the Ramsey Foundation.

OF-97-137

DIFFERENT EFFECTS OF RESPIRATORY MUSCLE STRETCH GYMNASTICS AND INSPIRATORY MUSCLE TRAINING IN PATIENTS WITH COPD

Tetsuo Miyagawa RRT RPT RCET, Hideko Kobayashi MD, and Fumio Kokubu MD,Ph D for the Respiratory Muscle Conditioning Group

Introduction: Respiratory muscle stretch gymnastics (RMSG) has been proposed as a possible new rehabilitation protocol for patients with chronic obstructive pulmonary diseases (COPD). The purpose of the present study was to compare the effect of RMSG with that of inspiratory muscle training (IMT) using the device Threshold^{TM}

Methods: Sixteen naive patients with COPD were entered in the study They performed IMT (2 sessions of 10 minutes of training at 30% of PImax, daily) for 4 weeks and RMSG (3 sessions of 5 RMSG patterns 4 times each, daily) for 4 weeks, in a randomized order, with a 4-week washout period in-between. Evaluating personnel were masked regarding each patients' schedule. Four patients dropped out due to pre-determined criteria.

Results: Results shown are mean values (n=12).

	IMT			RMSG		
	before		after	before		after
PImax (cmH$_2$O)	66 1	**	79 1	66.0		69 3
expansion (cm), lower chest wall	4 45	*	5 91	4 33	*	5 91
total lung capacity (ml)	5275		5348	5424		5301
functional residual capacity (ml)	3345		3351	3407	*	3250
residual volume (ml)	2212		2210	2308		2239
6-min walking distance (6MD) (m)	385	*	412	383	*	430
150mmVAS at the end of 6MD (mm)	5 3		4 8	5.0		4 3
VAS/6MD (10^3)	14 3		12.3	14 1	*	10 4
Chronic Respiratory Questionnaire	100		106	106	*	116

(*, P < 0.05, **, P < 0 01 comparing values before and after each rehabilitation protocol)

There were no significant changes in VC, FEV$_1$, PFR nor in the arterial blood gas analysis with either rehabilitation protocol

Conclusion: The results suggest that decrease in FRC is a unique feature of RMSG This may suggest that RMSG decreases chest wall stiffness RMSG may have clinically significant benefits for patients with COPD

Secretarial office of the Respiratory Muscle Conditioning Group, Second Department of Physiology, Showa University School of Medicine, Tokyo 142 Japan

OF-97-151

PROSPECTIVE EVALUATION OF NONINVASIVE POSITIVE PRESSURE VENTILATION (NPPV) FOR ACUTE RESPIRATORY FAILURE(ARF) IN COPD PATIENTS(PTS)

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We have presented the results of NPPV therapy for a diverse pt population in the acute care setting using a prospective registry and standardized respiratory therapist driven protocol (RespCare Vol 41, p 945,10/96) The COPD population is generally regarded as a more difficult group in which to achieve success with NPPV but specific and uniform criteria compromise comparisons between studies We now report a 9 month experience with NPPV in 38 COPD pts with ARF that includes APACHE scoring data and post hospital discharge outcome The 38 pts includes 23 males/15 females with a mean ± standard deviation age of 69 6 ± 8 8 yrs and body mass index (kg/m^2) of 26 6 ± 7 5 There were 20 pts who had been intubated in the past, and a "do not resuscitate status" was noted in only 8 pts A pt triggered mode was used in all cases with a backup timed machine rate added in 47% pts The mean inspiratory and expiratory pressure settings of the selected ventilator assist device were 11 8 ± 2.3 and 4 6 ± 0 9 cm H$_2$O respectively A full face mask was preferred over a nasal mask by 78 9% of pts The pts continued actual NPPV use for 23 2 ± 18 hours over 2 8 ± 2 5 days during a total hospital stay of 19 7 ± 16 9 days There were 16 pts who were either stabilized or improved with NPPV in the hospital and 22 pts either refused to continue (11 pts) or failed the therapy and required intubation (11 pts) There were 6 pts worse or expired by the hospital discharge date but when the follow-up outcome was assessed (at 34 5 ± 30 3 days), 24of 31 pts were stable or improved In comparing the 23% pts with death or worse outcome vs 77% pts stable or improved at 1 mos follow-up, the APACHE II scores on admission (47.7 ± 19 6 vs 32.3 ± 19 7) were significantly different (p < 0 05) The APACHE II scores in pts who were acutely stabilized or improved were however, not significantly different between admission and discharge We conclude that although APACHE scores were helpful in predicting final outcome after NPPV in COPD pts, the scores were not useful in tracking progress of pts who were stabilized or improved during NPPV therapy In comparing this COPD group to our previously reported overall NPPV population, there was no significant outcome difference, i e 57 8% of COPD pts vs 66% overall who were introduced to NPPV for ARF were initially stabilized or improved while 28 9% vs 19 6% actually required intubation **This work was supported in part by an unrestricted grant by Respironics Inc., Murraysville, Pa.**

OF-97-153

THE DIFFERENCE IN KNOWLEDGE AND PATIENT SATISFACTION IN PATIENTS WHO RECEIVE PULMONARY INSTRUCTION VIA LECTURE OR VIDEOTAPE---

Kelly S. Becker, B S., CRTT, Phillip D. Hoberty, EdD, RRT, and Rebecca J Hoberty, B.S., RRT, The Ohio State University, Columbus, Ohio

Background. Pulmonary Rehabilitation (PR) is a multifaceted, small group, interdisciplinary program consisting of progressive exercise training, breathing retraining, education and psychosocial support. The education component of a PR program is usually accomplished through use of lecture/discussion sessions conducted by clinicians who are knowledgeable in their given content areas. This method is costly and inefficient due to the repetitive use of the live presenters for each new group of patients. Audio-visual programs (AVP) that accomplish the same educational objectives as the live lecture/discussions and are delivered by the original presenters in a pre-recorded format may be a more advantageous method This would also facilitate multiple entry points for patients into the program, the make-up of missed educational sessions, and the modularization of the educational components so that patients would only view the modules that are needed. Two research questions were to be answered by this project: 1) is there a difference in knowledge level, and 2) is there a difference in patient satisfaction between the patients who attended live presentations and the patients who attended the AVP of the same content? The null hypothesis states that their would be no difference in knowledge or patient satisfaction levels between the lecture and video group The research hypothesis states that patients who receive instruction via AVP will have lower levels of both knowledge and patient satisfaction. Method: A control group consisted of 14 patients who received the educational portion of the program by lecture/discussion method. One round of these lecturers was used to create the video to be seen by the experimental group An experimental group consisted of 10 patients who received the educational component by viewing the video that was created in the control group. Both groups consisted of a sample of convenience The age of the patients in the two groups were not significantly different. Patient knowledge was evaluated by using pre- and post-test multiple choice test that was written by the presenters and validated by respiratory care students and practitioners with training in rehabilitation Patient satisfaction was assessed by a questionnaire created by the pulmonary rehab staff with input from the researchers Results: Using an alpha level of 0.05 as significant, the results of an ANOVA with repeated measures showed that both groups improved significantly on their post-test scores. There was no significant difference of knowledge level gained between the lecture and video group. There was no significant difference in the satisfaction level between the lecture or video group Also, age and educational level did not have a correlational effect on the results of the post-test Conclusions: There was no significant difference in the use of video versus lecture/discussion method of conveying the educational components of a PR program We find that it would benefit the PR program on the basis of cost and efficiency to use the AVP in place of the lecturers to provide the educational component of the PR program.

OF-97-165

CHANGE IN LUNG MECHANICS DURING CHEST PHYSICAL THERAPY TECHNIQUES

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Introduction: Chest physical therapy techniques are commonly performed for patients to enhance secretion clearance. However, the effect of these techniques in lung mechanics has not been studied. The purpose of this study was to evaluate the change in lung mechanics, especially expiration flow rate, during application of the chest physical therapy techniques.

Method: The subjects were 9 patients with acute respiratory failure who were 68.6 ± 8.8 years old, and all patients were intubated. We performed 3 techniques (squeezing, vibration and percussion), which were done in a standard fashion. We measured peak expiratory flow rate (PEFR) by a Bicore CP100 monitor (Bicore, Irvine, Ca). Tube with esophageal catheter was inserted to some subjects to observe esophageal pressure and a pressure–volume curve (P–V curve). Base line was measured on a lateral position and then all three techniques, in a randomized order, were applied for 5mins each, to subjects in the same position. Between techniques subjects took a rest to bring PEFR back to the base line. Statistical analysis was done using ANOVA.

Results: There was significant difference in PEFR between squeezing and the other techniques (p< 0.01). However, there was no difference between vibration and percussion. P–V curve changed during squeezing. V tended to increase during application of the squeezing.

Conclusion: The results of this study suggest that squeezing is the most effective technique, among the three performed in this study, to increase PEFR and V- It is helpful to remove secretion for patients who can not cough voluntarily.

OF-97-168

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PULSE DOSED INHALED NITRIC OXIDE THERAPY FOR A PATIENT WITH PRIMARY PULMONARY HYPERTENSION

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INTRODUCTION Inhaled nitric oxide (NO) is a selective pulmonary vascular smooth muscle relaxant. It readily crosses the alveolar endothelial membrane to cause relaxation in the underlying vascular smooth muscle. This decreases the pulmonary artery pressure and improves the ventilation-perfusion relationship without adversely affecting the systemic vascular resistance. NO then passes through the alveolar capillary membrane and is deactivated as it binds to hemoglobin.

CASE SUMMARY The subject is a 47 year old female who was diagnosed with primary pulmonary hypertension in 1986. Her condition deteriorated and she was listed for lung transplantation. The patient declined lung transplantation) secondary to improvement with medical management and transtracheal oxygen. She was referred for a trial of pulse dosed inhaled nitric oxide in June 1996 after her condition progressively deteriorated following general anesthesia and surgery for an unrelated condition. She was admitted to the SICU where a Swan-Ganz catheter was placed and she was given a trial of pulse dosed inhaled nitric oxide (NO) via nasal canula. A standard oxygen pulse dose delivery system (PDDS) (DeVilbiss OMS-50) was modified according to Channick et al (Chest1996;109:6:1545-1549) and attached to an 80 PPM source of nitric oxide.The actual calculated delivery is equal to 20 PPM +/- 5 PPM based on changes in respiratory rate, tidal volume and inspiratory flow rate.

Administration of NO resulted on a 16% decrease in mean Pulmonary artery pressure. The patient was discharged home with NO and instructed to use it 24 hrs/day. Our home based NO equipment includes one PPDS on a 4,100 L NO tank for use in the home and one PDDS on a 580 L NO tank as a portable system for use outside the home. 4,100 L tanks have lasted an average of 10 days (average cost $36/day). 580 L tanks have lasted an average of 24 hours (average cost $5.80/ hour) Objective measures of continuing success of NO include a 26% increase in distance walked in a standard 6 min. walk test and 16% decrease in systolic pulmonary artery pressure per echocardiogram at the six month follow up. The patient indicates marked improvement in the quality of her life, as assessed by standardized questionnaire (Rand Health Sciences Program)

DISCUSSION We have shown that that patient's resting oxygen requirement has been reduced from 3 L to 1 L, her quality of life has improved and she has resumed activities she had become physically unable to do. Additionally, we have been able to trigger the PDDS through a transtracheal oxygen catheter (while delivering oxygen through a nasal cannula). In conclusion we have shown that long term NO therapy is safe and effective with the use of a pulsed dose system. Greater savings may be possible with NO via transtracheal catheter.

OF-97-051

TRANSPORTING WITH NITRIC OXIDE USING A LOW FLOW BOURDON GAUGE

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BACKGROUND Therapies such as hyperoxygenation, hyperventilation, and intravenous vasodilators have provided limited success in reversing persistent pulmonary hypertension of the newborn, and hypoxemic respiratory failure Nitric oxide (NO) is an investigational new drug for the treatment of these disorders On occasion, patients fail NO treatment and must be referred to an ECMO center However, dependency on NO necessitates continuation of treatment during transport Otherwise, the patient clinically deteriorates The most common method of supplying NO during transport has been with a manual resuscitation device which is supplied with a blend of oxygen and NO delivered from separate flowmeters Because such a low flow of nitric oxide is required, and because they are difficult to regulate, we had concerns about our ability to provide a stable NO flow during transport using a flowmeter We evaluated the delivered accuracy of low flow bourdon gauges Evaluated were a Flotec model RRN0S4SSC4, Flotec Inc , Indianapolis, IN Western Medica model XA-2801, Westlake, OH, Victor model LSS-64, Victor Medical, Denton, TX low flow bourdon gauges compared to calculated values and Timeter model Classic 200 or 1000 low-flow flowmeters, Allied Healthcare Products, Inc , St. Louis MO METHODS A test circuit was assembled which consisted of a Y-connection having a common feed into 28 inches of aerosol tubing Oxygen, at 10 LPM, supplied 1 side of the Y-connection NO in the concentration of 800 ppm, (balance nitrogen) was delivered by the bourdon gauge to the other port of the Y-connection The common outlet of the Y-connection was connected to the test circuit using 18 inches of O2 supply tubing Bench testing was performed on 4 bourdon gauges at the following settings, (Flotec at 0, 20, 25, 50, 100, 250, 500, 750, and 1,000 ml, Victor Medical at 0, 100, 500, and 1,000 ml; Western Medical at 0, 250, 500, 750 and 1,000 ml) The gauges were set to comparative settings common to the other gauges tested We then tested delivered NO using the Timeter flowmeters, at 0, 20, 25, 50, 100, 250, 500, 750, and 1,000ml Testing consisted of three 10 minute runs at each setting with 0, 5 and 10 cmH20 of PEEP During each of the trials the delivered NO concentration was continuously sampled using a side stream analysis method Analysis was performed using an electrochemical device (Pulmonox II, Pulmonox Medical Corporation Canada) The measurements were recorded at 10 minute intervals The analyzer was calibrated per manufacturer's instructions Results were compared to the calculated value for the settings tested This calculation is represented by the following equation [NO dose = NO source ppm (NO flow rate/total flow rate)] RESULTS Calculated and mean measurements, with SD, of NO delivered and correlation between measured NO and calculated NO are in the following table

	Flowrate (ML/MIN)								
BRAND	0	20	25	50	100	250	500	750	1000
CALCULATED	0.0	1.0	2.0	4.0	7.9	19.5	38.0	56.0	73.0
Timeter Classic	0.0	0.0	1.7(0.6)	2.0(0)	7.3(1.2)	19.3(1.2)	36.7(1.2)	56(2)	73.3(3.1)
FLOTEC	0.0	0.0	0.0	0.3(.6)	5.3(4)	20(4)	39.3(3.5)	54.3(5.5)	73(7.8)
WESTERN	0.0					26(1)	45(4)	64.3(5.7)	84(7.5)
VICTOR	0.0				8.7(1.2)		36.3(2.3)		73.3(7.6)

Correlation. Timeter 1.0 Flotec 1.0 Western 1.0 Victor 1.0

CONCLUSION Bourdon gauges deliver reasonably accurate flows, of NO at settings ≥ 100 cc/min There is a high correlation of NO delivery when compared to calculated predicted values Bourdon gauges can be a reasonable alternative to flowmeters for providing safe NO delivery while transporting patients with or without PEEP They are less susceptible to accidental mis-dosing when compared to flowmeters

OF-97-067

EVALUATION OF THE SENSORNOX NITRIC OXIDE/NITROGEN DIOXIDE ANALYZER.

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The measurement of nitric oxide (NO) and nitrogen dioxide (NO_2) concentrations is an important component of an inhaled NO delivery system. We evaluated the SensorNOx NO/NO_2 monitor (SensorMedics Corp, Yorba Linda, CA). The monitor was calibrated according to the manufacturer's specifications. NO from an 800 ppm source tank was titrated into the inspiratory limb of a VIP Bird ventilator. The ventilator, attached to a test lung, was set in the IMV mode at a PiP/PEEP of 30/5 cmH_20, rate of 30, and a Ti of 0.6 secs. Predicted NO concentrations were determined from the equation, $[NO_{PRED}] = (NO_{SOURCE})(\dot{V}_{NO})/(\dot{V}_{NO} + \dot{V}_{VENTILATOR})$. All flow rates were verified and 7 $[NO_{PRED}]$, range 2.5-80 ppm, were used. Following 5 minutes of stabilization, NO and NO_2 measurements were recorded for each $[NO_{PRED}]$ and at a set FDO_2 of 0.3, 0.6 and 1.0. The study was repeated 5 times and $[NO_{PRED}]$ was compared to measured NO. The bias ± precision between $[NO_{PRED}]$ and measured NO was -0.26 ± -0.39 ppm (p=0.17). The mean % bias was -0.84% and the limits of agreement were -1.96 to 1.44 ppm. The bias at each FDO_2 was -0.94 ppm at 0.30, -0.30 ppm at 0.60 and 0.45 ppm at 1.0. There was a significant difference in bias between FDO_2 of 0.30 and 1.0 (p=0.003). The mean NO_2 measurements were 0.03 to 1.72 ppm. This monitor provided accurate measurements of NO concentrations and is suitable for clinical use. The increase in bias as FDO_2 is increased would not be significant in the clinical setting. We have found this monitor easy to use, and that the side-stream sample design provides the capability of measuring environmental NO and NO_2 levels.

OF-97-109

INHALED NITRIC OXIDE TO ENABLE APNEA TEST FOR THE DIAGNOSIS OF BRAIN DEATH

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The diagnosis of brain death (BD) is important to facilitate organ retrieval for transplantation and to reduce futile care The diagnosis of BD requires performance of an apnea test (AT) at which time the patient is monitored for attempts of spontaneous ventilation while pCO2 is allowed to increase to maximally stimulate the respiratory center in the brain stem Lack of respiratory effort when a pCO2 of 60mm Hg is reached, indicate death of the brain stem and is an essential component of the diagnosis of brain death During the performance of AT , the patient is disconnected from the ventilator, and oxygenation is maintained by intra-tracheal insufflation of oxygen at 5-10 LPM. In some patients, severe lung injury may preclude performance of AT because of the development of severe hypoxemia upon disconnection from the ventilator We report the case of a patient in whom the use of inhaled nitric oxide prevented hypoxemia during AT and enabled determination of BD

A 30 year old man was admitted to the intensive care unit with multiple trauma after a motor vehicle accident His injuries included severe head trauma, Glasgow coma Score-3, lung contusion, abdominal injury and multiple fractures The patient required significant ventilatory support to achieve adequate oxygenation and ventilation He was managed with pressure controlled ventilation (7200, Puritan Bennett, Carlsbad, CA) FiO2-1 0, PEEP - 10 cmH2O, I E ratio 2:1, to maintain SaO2 of 94-97%. Cardiac output and systemic blood pressure were maintained byfluid replacement, intravenous adrenaline (0 05-0.15 mcg/kg/min) and pitressin (2-4 units/hour) Twenty four hours after arrival in the intensive care unit, evaluation for BD revealed no brain stem responses Two attempts at conventional apnea testing failed because of a rapid decline in saturation upon disconnection from the ventilator This desaturation occurred despite continuos flow of oxygen and a CPAP of 10 cmH2O. We therefore attempted to perform an apnea test while delivering nitric oxide to the patient. The test was performed by introducing continuous flow of NO (800PPM NO in N2) into the inspiratory limb of the ventilator The NO level was measured with an electrochemical sensor system (NOxBox, Bedfont Ltd , UK), which measures NO and NO2 concentrations The monitor sampled intra-tracheal gas through a catheter inserted into the endotracheal tube Following 5 minutes of stabilization, the patient was disconnected from the ventilator, and oxygen, and low flow of NO were maintained for 10 minutes This enabled blood gases to reach levels consistent with maximal respiratory center stimulation (pCO2>60mmHg) while pO2 remained adequate (pO2>50mmHg)

The performance of AP was completed and the patient declared brain dead The patient was then connected to the ventilator, and inhalation with NO was maintained Twelve hours later, when the patients family declined the option of organ donation, inhaled NO was withdrawn, which led to a rapid decline in PaO2

In selected patients in whom AT cannot be performed due to severe lung injury, inhaled NO may improve oxygenation, and enable brain death determination

OF-97-115

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AMBIENT NO/NO_2 LEVELS DURING INO THERAPY *WITHOUT* EXPIRED GAS SCAVENGING

Bill Phelan RRT Maine Medical Center Portland, Maine

Standard practice for Inhaled Nitric Oxide programs involves scavenging exhaled gas to keep ambient / background levels of NO & NO_2 below OSHA specified levels Anecdotal information suggest that rooms with an air exchange rate of >8x/hr may provide adequate circulation to keep background NO / NO_2 below these levels. The Occupational Safety & Health Administration [OSHA] limits 8 hour Time Weighted Average [TWA] exposure to 25ppm NO & 5ppm NO_2. Short Term Exposure Limits [STEL] are listed at 5ppm NO & 1ppm NO_2.

We hypothesized that our air handling system would circulate the environment sufficiently to keep background levels of NO & NO_2 at acceptable levels.

A VIP Bird Ventilator (Bird Products, Palm Springs, Ca) was configured for Time cycled/pressure limited [TCPL] continuous flow ventilation. The total ventilator flowrate was set at 10lpm & 20lpm Using inspiratory limb titration, 800ppm NO (BOC Gases, Port Allen, La) was introduced into the circuit via a DeINO 2000 mass flow controller (Sensormedics Critical Care, Yorba Linda, Ca), resolution 0.01lpm We utilized a 2030 ft^3 ICU room with an air exchange rate of 8 exchanges per hour [200 ft^3/min] Circuit gas as well as ambient room air was analyzed using a Sievers 280NOA (Sievers Instruments, Boulder Colorado) chemiluminescent NO/NO_2 analyzer, resolution 1ppb After 2 point calibration of the analyzer, we sampled exhaled gas at a variety of NO & FiO_2 settings Gas was sampled at the inspiratory side of the patient wye, as well as at the exhalation valve outlet, and at points 2 ft, 4ft & 7ft from the exhalation valve at a height of 5ft

Results summarized below values are expressed in parts per million [ppm]

NO dose	40ppm				20ppm			
Vent flow	10 lpm		20 lpm		10 lpm		20 lpm	
FiO_2	21%	100%	21%	100%	21%	100%	21%	100%
circuit NO	0 783	1 320	0 831	1 29	0 386	0 479	0 380	0 501
X-valve NO	9 800	9 700	9 100	9 200	3 300	3 400	3 400	3 400
NO_2	0 197	0 354	0 224	0 410	0 097	0 186	0 143	0 263
2' out NO	0 113	0 109	0 155	0 147	0 094	0 090	0 118	0 120
NO_2	0.087	0 195	0 099	0.227	0 036	0 088	0 039	0 097
4' out NO	0.067	0 060	0 114	0 096	0 038	0 039	0 040	0 041
NO_2	0.065	0 089	0 078	0 098	0 044	0 078	0 048	0 089
7' out NO	0 044	0 039	0 067	0 070	0 038	0 038	0 042	0 042
NO_2	0 034	0 043	0 039	0 051	0 032	0 034	0 034	0 040

From this date we conclude that, in those patients receiving ≤40ppm NO, in rooms with air handling systems with 6 or more exchanges per hour, ambient NO & NO_2 levels are maintained well below OSHA mandated standards for care giver exposure Further work examining ambient NO/NO_2 levels from systems with higher flowrates & NO doses, rooms with less efficient ventilation systems, as well as the implications of exposure to >50 parts per *billion* NO_2 may still needed

OF-97-128

SODA LIME CANISTER USED AS A NO2 SCRUBBER DURING NITRIC OXIDE ADMINISTRATION

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Introduction: At our institution we have delivered nitric oxide (NO) to patients with ARDS and pulmonary hypertension via NPB 7200 ventilator A consequence of mixing NO with oxygen in the ventilator or ventilator circuit is the formation of nitrogen dioxide (NO2), a highly toxic gas Although the EPA time weighted average (8hrs) limit on NO2 is 5ppm , it has been documented that as little as 2ppm can cause cellular change At our institution the limit for NO2 is 1ppm We devised an experiment to measure NO2 delivered to the patient in a simulated clinical condition in order to estimate the efficiency of a soda lime canister in removing NO2 **Methods**: 800ppm NO source is mixed with clinical air in a modified Bird 3800 blender The outlet of the blender connects to the air inlet of the 7200 ventilator where it mixes with oxygen inside the ventilator The resulting NO-O2-N2 is delivered to the patient via a standard heated wire ventilator circuit The NO2 scrubber was placed in the inspiratory limb 12" from the ventilator outlet NO2 samples were taken pre and post scrubber at FIO2's 50,.70,.90, and NO settings of 10, 20 and 40 ppm as measured post scrubber A calibrated ElectroChemical NO/NO2 analyzer (Micro Direct Printer Nox) was used for all measurements. Ventilator settings were CMV, Vt 800cc, RR 12, flow 50lpm Results Results are concentrations of NO2 pre and / post scrubber expressed in parts per million (ppm).

		Oxygen Concentration		
		.50	.70	90
NO ppm	10ppm	15/ 05	15/ 05	40/ 1
	20ppm	.35/ 20	55/ 25	1 35/ 30
	40ppm	1 0/ 5	1 75/ 60	3 0/ 85

At all settings tested the soda lime cannister maintained a <1ppm NO2 in the inspiratory limb The soda lime removed <1ppm of NO on any setting tested **Conclusion**. Commercially manufactured soda lime canisters can be an efficient method of removing NO2 from the ventilator circuit Issues such as the effect of the canister on ventilator function and the effective life of the soda lime need to be evaluated

OF-97-162

A NOVEL BREATH-ACTUATED SMALL VOLUME NEBULIZER UNDER SIMULATED ADULT USE CONDITIONS

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Trudell Medical, London, Canada

Pneumatic small volume nebulizers (SVNs) in which atomization only occurs during the inhalation phase of the breathing cycle has important ramifications in terms of the efficiency of medication delivery. We report an investigation in which the effectiveness for the delivery of salbutamol (Ventolin® nebules: 5 mg/2.5 ml, Glaxo Wellcome, Canada) via a prototype breath-actuated SVN (Trudell Medical, Canada (TRU) was compared with that of a high performance closed-system SVN (Ventstream™, Medic-Aid, Pagham, U K (VEN)). Each nebulizer was connected in turn to a dual-chambered test lung with one chamber driven by a ventilator and the other connected to the SVN mouthpiece. Aerosolized salbutamol delivered on inhalation (800 ml tidal volume, I/E of 1/1, 15 breaths/min) was collected on a filter (Filtrete™, 3M Corp., St Paul, MN) located at the mouthpiece Oxygen (440 kPa, 8 l/min) was used to operate each SVN, and the contents of a single nebule (2.5 ml) were added to the reservoir at the start of each test. Over a 5 minute period of use, the TRU SVN provided 1.74 ± 0.04 mg salbutamol to the filter (n=5 replicates), significantly more than the VEN which delivered 1 28 ± 0.01 mg in 3.5 min (Mann Whitney Rank Sum Test, p = 0.008), after which the device sputtered dry (n = 5 replicates). These data indicate that the new breath-actuated device may have important benefits in reducing wastage of medication by operating more efficiently, as well as reducing exposure to the care-giver

OF-97-028

EVALUATION OF THREE METHODS FOR DELIVERING AEROSOLIZED ALBUTEROL TO A SPONTANEOUSLY BREATHING TRACHEOSTOMY MODEL ON A CONTINUOUS HIGH FLOW BLOWBY SYSTEM

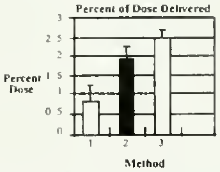
David Blakeman AS SRCP, Scott Fedrizzi MPA RRT, Andrea Easley, SRCP, Butte Community College, Oroville, CA.

Introduction After an extensive literature review, we found no documented evidence regarding the delivery of aerosolized bronchodilator treatments to spontaneously breathing tracheostomy patients on continuous high flow blowby systems Therefore, we developed a bench model to evaluate 3 methods for delivering aerosolized bronchodilator via Small Volume Nebulizer (SVN) treatment to a spontaneous breathing tracheostomy model attached to a continuous high flow blowby system calibrated to 70 liters per minute

Study Question Does method of delivery affect medication deposition and FIO_2 delivered?

Methods Work of Breathing (WOB) studies conducted were acceptable for all 3 methods Carbon Dioxide (CO_2) rebreathing study proved negative Five SVN's from the same lot were pretested for comparability The 3 methods used for delivery of the SVN treatments are as follows, Method 1) SVN placed inline of large bore tubing 18" upstream from trach T-piece with 6" reservoir tubing, Method 2) "Mask on Trach Mask Technique" This consists of a SVN attached to large bore tubing connector of trach collar with aerosol mask connected to high flow held over the trach collar, Method 3) "T Reservoir Technique". This consists of a delivery system of 6" high flow tubing connected on one end to the trach tube and on the other end to SVN T-piece, followed by 12" high flow tubing connected to the high flow blowby tubing T-piece. Five trials for each of the three delivery methods were performed A double-sided test lung with lift bar was used to simulate spontaneous breathing One side of the test lung was attached to the Hamilton Veolar (Vt 700, rate 12/min, sine wave, flow 60 L/min) and the other side was attached to Tygon tubing, (10 1/2 cm long, with 2 cm diameter), which was intended to simulate the trachea of a spontaneously breathing patient An 8 mm ID trach tube was inserted into the tubing and cuff was then inflated. 100% cotton wadding was place in a collection chamber approximately 5 1/2 cm from end of trach tube The tracheal model was maintained at approx 85 degree angle to prevent drops from contacting the cotton SVN's in all methods were run until sputter, tapped 6 times and run until sputter again. Albuterol drug was extracted from the cotton using a previously described method (Resp. Care 1992 37.1233) The extracted solution was filtered through a slow-flow paper filter to remove any cotton fibers or impurities. Absorbance was measured at 278 nm (Perkin Elmer low beam spectrophotometer). The amount of albuterol extracted from the cotton was calculated based on the known standard solution (0.05 mg/ml) using a modification of Beer's Law

Results Method 1 and 3 consistently delivered the set (50%) FIO_2 while method 2's FIO_2 was variable Method 1 delivered 0 86% of the total dose Method 2 increased drug delivery to 1 98% of the total dose. Method 3 increased drug delivery still further to 2 49% ANOVA for repeated measures revealed significant differences between the 3 methods (p< fl1)



Conclusion Method 3, "T Reservoir Technique", delivered reliable FIO_2 and consistently demonstrated greater deposition as compared to the alternate methods evaluated Although Method 2 had better deposition than Method 1, FIO_2 was variable Our results show that our T Reservoir Technique is a superior method for delivering aerosolized medication under these particular conditions

The authors wish to thank Jerry Hunt, MS, RRT, RPFT for technical assistance and support.

OF-97-035

PROSPECTIVE CLINICAL COMPARISON OF TWO SMALL VOLUME NEBULIZERS IN PATIENTS WITH ACUTE RESPIRATORY DISTRESS TREATED IN THE EMERGENCY DEPARTMENT

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Introduction: We prospectivly evaluated the effectiveness of a new small volume nebulizer (SVN), the Circulaire (WestMed Mfg, Tuscon, AZ) comparing it's clinical performance to the Micro Mist (Hudson RCI, Temecula, CA) SVN we currently use.

Methods: 52 patients in acute respiratory distress treated in our hospital emergency center were entered into this study. All patients received albuterol sulfate 2.5 mg per treatment. Our Lead Respiratory Therapists measured treatment time, pre/post peak flow, and had the patient score their respiratory distress The Lead Respiratory Therapists also recorded the patients age, sex, diagnosis and number of treatments administered prior to discharge from the Emergency Center

Results: We performed 2 sample t-test statistical analysis on the patient data reported below, using Statisux software (Tallahassee FL). A p value of less than 0.05 was considered significant. The patients were asked to rank their breathing problem on the following three point scale;

1 = mild breathing distress
2 = moderate breathing distress
3= severe breathing distress

Data:	Micro Mist	Circulaire	p value
n	13	39	
Age (years)	42.2 +/-20.7	51.1+/- 22.4	.36
Resp Distress (1-3)	1.6+/- .51	1.8 +/- .66	.09
Disease Distribution (%)			
Asthma	69%	62%	
COPD	21%	23%	
Bronchitis	10%	15%	
Change Pre Post (lpm)	59.0+/- 47.5	41.4+/- 51.6	.35
Change Pre Post (%)	.29 +/- .24	.24 +/- .30	.11
Treatment Time (min)	11.3 +/- 3.9	7.5 +/- 2.7	.04
% pts requiring 2nd SVN	62%	31%	

Conclusion: The two populations appear to be comparable for age and respiratory distress. There appears to be no difference in the change in peak flow for the two patient populations. The Circulaire required significantly less time to treat the patient. Also, 62% of the Micro Mist patients required a second treatment while 31% of the Circulaire patients required a second treatment prior to discharge from the Emergency Department. We conclude the Circulaire is superior to the Micro Mist due to the reduction in treatment time (personnel costs) and effectiveness (less repeat SVN).

OF-97-038

COMPARISON OF THE MINISPACER™ WITH A SINGLE-SPRAY MDI DISPENSER IN AN HCH CIRCUIT

Paul D McGowen RRT, Columbia El Dorado Hospital and Thayer Medical Corporation, Tucson AZ, Scott A Foss BS, Thayer Medical Corporation, Tucson AZ

Background: The Airlife™ Dual Spray MiniSpacer is designed to deliver MDI drugs in a ventilator circuit by splitting the aerosol spray into two plumes The purpose of this laboratory experiment was to determine the dose output of the MiniSpacer in comparison with the single-spray Airlife™ Metered Dose Inhaler Dispenser/Adapter ("Standard MDI"), when used in conjunction with a Baxter Adult Filtered Hygroscopic Condenser Humidifier (HCH) **Method:** In the experimental setup, a Harvard Breathing Machine was attached to a patient wye, which was followed by the HCH The MDI delivery device was placed immediately downstream from the HCH, the Standard MDI spray was directed downstream, away from the HCH Proventil® (albuterol) was the MDI drug used The delivery device fed into an ET tube, and at the end of the ET tube a filter trapped the drug particles from each dose A humidifier (at 33 C) after the filter mimicked the high humidity of a patient's breath The total mass dose output (MDO) was measured for each device with proper timing for the actuation, that is, the canister was actuated immediately after the start of inhalation of the breathing machine The breathing machine was set for six cycles/minute, 800 cc/cycle Ten sample devices of each type (MiniSpacer and Standard MDI) were tested In the sequence of trials, one MiniSpacer was tested, then one Standard MDI, and so on, to avoid any systematic bias For each sample device a uniform procedure was followed

1 The device was set into a clean circuit (with a new HCH) and left for ten minutes, to allow the RH in the ET tube to reach equilibrium
2 The canister of Proventil was shaken vigorously and the nozzle was inserted into the MDI port of the delivery device
3 The canister was actuated at the start of inspiration
4. Steps 2 and 3 were repeated nine more times
5. The filter was removed from the circuit, capped, and labeled

When all 20 trials were completed, each filter was analyzed as follows

1 20.0 mL of phosphate buffer was pipetted into the filter
2. The filter was shaken for about a minute to dissolve the albuterol into the phosphate buffer, and the solution was then poured into a flask
3 The solution was analyzed spectrophotometrically to determine the amount of albuterol collected on the filter (that is, the total MDO)

Results: The table below gives the average total MDO for each type of device

Device	Total MDO (micrograms/dose)	One standard deviation (micrograms/dose)
MiniSpacer	**20**	3
Standard MDI	**14**	1

Conclusion: With placement immediately downstream from an HCH, the MiniSpacer delivered approximately 40% more Proventil than the Standard MDI A t-test shows that the difference is statistically significant, since the p-value is 6 8 $\times 10^{5}$ As always, laboratory results do not necessarily indicate what clinical results would be

OF-97-046

RESPIRABLE DOSE OUTPUT COMPARISON OF FOUR MDI SPACERS

Scott A. Foss BS, Joseph N. Lix BA, David T. Sladek CRTT, Jean W. Keppel PhD, Thayer Medical Corporation, Tucson AZ; Paul D. McGowen RRT, Columbia El Dorado Hospital and Thayer Medical Corporation, Tucson AZ

Background: This laboratory study compares the performance of four hand-held MDI spacers the Airlife™ Hand Held MediSpacer®, the Aerosol Cloud Enhancer (ACE®), the OptiHaler®, and the AeroChamber®. Dose output and particle sizes were measured for three drugs Ventolin®, Alupent®, and Intal®. A cascade impactor (analogous to patient's lung) measured particle sizes and dose output at a constant air flow rate, while a breathing machine simultaneously regulated the flow of aerosol medication through a USP standard throat model (analogous to patient's throat). In all tests the MDI drug canister was actuated at the start of inspiration. Five different devices of each brand were tested with each drug. **Method:** Output of the spacer goes to the throat model, which feeds into a tee. One branch of the tee feeds into the cascade impactor, with constant flow rate 28 L/min maintained by a vacuum pump, the other branch attaches to a wye that has a breathing machine on one branch and a pressurized air source on the other. The air source is adjusted so that the net flow through the throat model = 0 before the breathing machine is turned on. Flow from air source to vacuum pump bypasses the throat, so flow through the throat is regulated entirely by the cyclic air flow of the breathing machine. **Results:** Two-tailed t-tests with unequal variances were done, any differences between the averages were considered statistically significant if $p < 0.05$

(1) *μg of drug per dose in respirable range (1-5 μm) reaching the cascade impactor*

Drug	MediSpacer	ACE	OptiHaler	AeroChamber
Ventolin	36 ± 3(StdDev)	26 ± 6	15 ± 4	24 ± 2
	Statistically equivalent ACE/AeroChamber (Others statistically different.)			
Alupent	103 ± 15	29 ± 3	38 ± 11	90 ± 30
	Statistically equivalent ACE/OptiHaler, and MediSpacer/AeroChamber			
Intal	339 ± 72	137 ± 82	84 ± 25	218 ± 58
	Statistically equivalent ACE/OptiHaler, and ACE/AeroChamber			

(2) *μg of drug per dose deposited in throat model.* The various drug/device combinations were statistically equivalent except for some differences with Intal

Drug	MediSpacer	ACE	OptiHaler	AeroChamber
Ventolin	0.8 ± 0.1	0.8 ± 0.2	0.8 ± 0.4	1.4 ± 0.6
Alupent	5 ± 3	3 ± 1	2.0 ± 0.4	12 ± 9
Intal	32 ± 14	11 ± 3	9 ± 3	19 ± 7

Conclusions: As is considered desirable, all four devices prevented large quantities of drug from being deposited in the throat model. With respect to respirable dose, the MediSpacer and the AeroChamber always outperformed the OptiHaler, and in 8 out of 9 cases the MediSpacer outperformed the other three devices. Possible reasons are (a) The volume of the OptiHaler is approximately half that of the other three, so more drug may impact the sides of the OptiHaler directly. (b) Unlike the AeroChamber and the ACE, the MediSpacer has its one-way valves placed outside of the air pathway, so none of the drug impacts a valve during inhalation.

OF-97-047

THROAT-MODEL DEPOSITION OF 20 MDI DRUGS, COMPARING THE MEDISPACER® WITH THE MANUFACTURER'S NOZZLE

David T. Sladek CRTT, Scott A. Foss BS, Thayer Medical Corporation, Tucson AZ

Background: Throat deposition is considered undesirable for drugs targeted to the lungs, as a concentration of the drug in the throat may cause side effects. All metered dose inhaler (MDI) canisters are offered with an aerosol delivery nozzle designed by the drug manufacturer. The Airlife™ Hand Held MediSpacer has a universal nozzle designed for use with all MDI drugs. This laboratory study compares the deposition of 20 MDI drugs onto a throat model when administered in two different ways, with the manufacturer's nozzle or with the MediSpacer. **Method:** The throat model was in-line between the MDI delivery device and a vacuum pump (air flow rate 28 L/min). For nine of the drugs (marked below with *) a glass throat model was used, for the other 11 the throat model was the USP standard aluminum version. After multiple doses were administered, the throat model was rinsed and the amount of drug in the rinsings was quantified using standard UV spectroscopic techniques. Five tests were averaged for each drug/device combination. **Results:** The table compares the percentage of the total drug/dose found in the throat-model rinsings, using the MediSpacer (Medi) and the manufacturer's nozzle (Mfr). Total drug/dose is the nominal amount listed on the label.

Drug	Total drug/ dose	% of total dose found in throat		Drug	Total drug/ dose	% of total dose found in throat	
		Medi	Mfr			Medi	Mfr
Steroid:				Bronchodilator (cont.):			
Aerobid*	250 μg	1.0%	39%	Brethaire	0.20 mg	3.5%	85%
Azmacort	200 μg	7.0	8.5	Bronkaid	0.25 mg	0.6	57
Beclovent	42 μg	1.2	45	Isuprel	131 μg	0.8	61
Flovent	220 μg	1.4	40	Maxair*	0.2 mg	1.5	70
Vanceril*	42 μg	0.5	36	Medihaler-Iso	0.08 mg	1.8	36
Anti-Inflammatory (non-steroid):				Primatene Mist	0.22 mg	0.7	65
Intal*	5 mg	12	76	Proventil	90 μg	4.4	52
Tilade	1.75 mg	1.0	62	Proventil HFA	108 μg	5.6	44
Bronchodilator:				Serevent*	21 μg	1.9	25
Alupent*	0.65 mg	2.2	63	Tornalate*	0.37 mg	1.4	32
Atrovent*	18 μg	2.7	14	Ventolin*	90 μg	4.4	53

Conclusion: For all drugs tested except Azmacort (whose nozzle has a built-in spacer), two-tailed t-tests show that these differences are statistically significant ($p < 0.05$). Spacers are usually not mentioned in the labeling of inhaled aerosol drugs however, a spacer will clearly be effective in reducing throat deposition of the active ingredient. This may be particularly beneficial in the case of inhaled steroids where throat deposition is known to lead to clinical complications.

OF-97-049

PERFORMANCE OF FOUR MDI SPACERS, WITH ACTUATION IN PHASE AND OUT OF PHASE WITH INHALATION

Scott A. Foss BS, Joseph N. Lix BA, Jean W. Keppel PhD, David T. Sladek CRTT, Thayer Medical Corporation, Tucson AZ, Paul D. McGowen RRT, Columbia El Dorado Hospital and Thayer Medical Corporation, Tucson AZ

Background: Many users of MDI spacers report difficulty in coordinating actuation of the MDI canister with inhalation. The purpose of this study was to find out how a lack of coordination might affect the amount of medication delivered to the patient's lungs. We tested four hand-held MDI spacers: the Airlife™ Hand Held MediSpacer®, the Aerosol Cloud Enhancer (ACE®), the OptiHaler®, and the AeroChamber®. Each brand of spacer was tested under two different conditions (a) "In Phase," MDI drug canister actuated at the start of inhalation, and (b) "Out of Phase," MDI canister actuated at the start of exhalation. A cascade impactor (analogous to patient's lung) measured particle sizes and dose output at a constant air flow rate, while a breathing machine simultaneously regulated the flow of aerosol medication through a USP standard throat model (analogous to patient's throat). Five different devices of each brand were tested, with Ventolin® (albuterol). **Method:** Output of the spacer travels to the throat model, which feeds into a tee. One branch of the tee feeds into the cascade impactor, with a constant flow rate of 28 L/min maintained by a vacuum pump, the other branch attaches to a wye that has a breathing machine on one branch and a pressurized air source on the other. The air source is adjusted so that the net flow through the throat model = 0 before the breathing machine is turned on. Flow from the air source back through the tee to the vacuum pump bypasses the throat model, so flow through the throat is regulated entirely by the cyclic air flow of the breathing machine. **Results:** Tabulated below are the averages for *μg of drug per dose in the respirable range (1-5 μm) reaching the cascade impactor.* Two-tailed t-tests with unequal variances were done, any differences between the averages (for In-Phase and Out-of-Phase) were considered statistically significant if $p < 0.05$. The p-values are given below. Also given for each device is the ratio of respirable dose In Phase to respirable dose Out of Phase:

	MediSpacer	ACE	OptiHaler	AeroChamber
In Phase (μg)	36 ± 3(StdDev)	26 ± 6	15 ± 4	24 ± 2
Out of Phase (μg)	24 ± 6	6 ± 4	1.3 ± 0.3	11 ± 3
p-value	0.005	0.0005	0.002	0.0002
Ratio, In-Phase: Out-of-Phase	1:0.67	1:0.23	1:0.09	1:0.46

Conclusions: For all four brands, the amount of drug delivered to the cascade impactor was significantly less in the Out-of-Phase case as compared with the In-Phase case. This decrease was not due to any change in μg/dose deposited in the throat, as t-tests gave $p > 0.05$ in the comparison of throat model washings for the In-Phase and Out-of-Phase cases (all four brands). Instead, washings from the spacers themselves showed that the decrease was due to leakage of drug out of the spacer (MediSpacer and ACE) or increased deposition of drug on the inner walls of the spacer (OptiHaler and AeroChamber). The main inference to be drawn is that, while device design is important, timing greatly affects the amount of drug delivered to the lung by any spacer.

OF-97-048

COMPARISON OF THE CLINICAL EFFECTS OF ALBUTEROL AEROSOL DELIVERY BY SMALL VOLUME NEBULIZER AND METERED DOSE INHALER IN INTUBATED, MECHANICALLY VENTILATED ADULTS

Sule Sonmez, M.S., RN, Amerikan Hospital, Istanbul, Turkey, Ceyhan Celikoglu, MD, Firuz Celikoglu, MD, Nahit Cokar, MD, Lufti Telci, MD, Istanbul University, Istanbul, Turkey, Randy De Kler, M.S., RRT, Georgia State University, Atlanta, GA

Background. The effective delivery of aerosolized medications to intubated, mechanically ventilated patients continues to challenge clinicians. Advantages and disadvantages exist for both the small volume nebulizer (SVN) and metered dose inhaler (MDI) methods. This study compared the clinical efficacy, based on selected assessment parameters, of the SVN and MDI aerosol delivery routes. Methods. 14 sedated, paralyzed, mechanically ventilated, adult COPD patients were included in the study group. Albuterol was administered to each patient alternately via the SVN and MDI route. Peak inspiratory pressure (PIP), plateau pressure (P_{PLAT}), airway resistance (R_{AW}), and auto-PEEP were measured before and fifteen minutes after each treatment. Results.

Mean decrease after treatment

	PIP	P_{PLAT}	R_{AW}	auto-PEEP
SVN	5.87	3.42	4.22	2.21
MDI	4.75	2.72	3.62	1.35
p	0.19	0.28	0.47	0.03

Conclusions. No statistically significant difference was found for PIP, P_{PLAT}, or R_{AW} between the two methods. The SVN method resulted in a decrease in auto-PEEP that reached statistical significance (p=0.03). This value, while statistically significant, may not be clinically important.

OF-97-087

SMALL VOLUME NEBULIZERS ARE INEFFECTIVE WHEN USED IN-LINE WITH HIGH FLOW OXYGEN THERAPY.

J. Dhaliwal RRT, K. Jager RRT, M Tweeddale MD. Vancouver Hospital & Health Sciences Center, Vancouver, Canada

Introduction: Bronchodilators are commonly administered through small volume nebulizers (SVN) placed in-line with a high O_2 flow. This study was designed to determine the efficacy of SVN treatment when given in-line with high flow O_2. **Methods:** A 2-chamber test lung was used to simulate a spontaneously breathing non-intubated patient. Simulated parameters were tidal volume 500 ml and rate 20/min, at inspiratory flowrates of 40 and 80 L/min. An aerosol mask was adapted to fit a filter which was connected to the 'patient' chamber of the test lung. All tests were made at both inspiratory flowrates, using 4 filters for each test. For each test, 5 ml normal saline were nebulized from a SVN using a driving flow of 8 L/min for 7 min, the filter being weighed before and after to determine the amount of saline which would have reached the test lung. Tests were repeated with the SVN in-line with high flow O_2 at 42 and 67 L/min, corresponding to an FiO_2 of 0.40 and 0.70. **Results:** Mean aerosol deposition ($\pm$SD) in the filters is recorded below.

Patient flowrate	SVN 8 L/min alone	42 L/min (0.40) (O_2 flow)	67 L/min (0.70) (O_2 flow)
40 L/min	^0.69 $\pm$ 0.03 g	*0.07 $\pm$ 0.02 g	*-0.07 $\pm$ 0.02
80 L/min	0.61 $\pm$ 0.02 g	*0.04 $\pm$ 0.00 g	*-0.08 $\pm$ 0.01

^ $p < 0.05$ vs SVN alone at 80 L/min, * $p < 0.001$ vs SVN alone

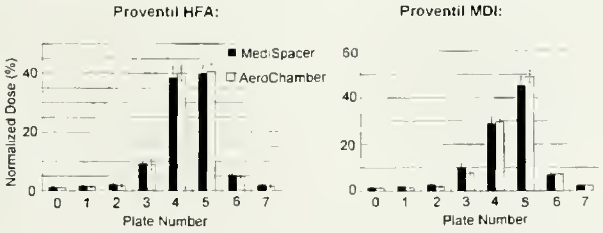
Conclusion: Both patient and O_2 flow factors influence aerosol deposition using SVN's. High flow O_2 effectively prevents aerosol delivery from the SVN to the patient. Therefore SVN's should not be used in-line with high flow oxygen.

OF-97-097

PARTICLE-SIZE COMPARISON OF MEDISPACER® AND AEROCHAMBER® IN THE DELIVERY OF PROVENTIL® HFA AND PROVENTIL® MDI

Scott A. Foss BS, David T. Sladek CRTT, Rebecca E English BS, Thayer Medical Corporation, Tucson AZ , Paul D McGowen RRT, Columbia El Dorado Hospital and Thayer Medical Corporation, Tucson AZ

Background: It is probable that by the year 2005 CFC propellants will be phased out of use in MDI canisters, to be replaced in many cases by HFA propellants. Proventil HFA is the first of the metered dose inhalers to have made the changeover, and it is expected that several more CFC-free MDIs will appear in the next few years The purpose of this laboratory study was to determine whether the particle size distributions of Proventil HFA (without CFCs) and Proventil MDI (with CFCs) are affected by the delivery nozzle We compared results from two hand-held MDI chambers the MediSpacer, which has a built-in nozzle, and the AeroChamber, which uses the manufacturer's nozzle **Method:** The MDI chamber fed into a USP standard throat model, which led to an Andersen cascade impactor, a vacuum pump kept the flow rate through the system at a constant 28 L/min After multiple doses were administered, the amount of drug deposited on each plate of the cascade impactor was determined by standard UV spectroscopic techniques The amounts were then normalized to the total amount collected in the cascade impactor Five tests were averaged for each device/drug combination Two-tailed t-tests were performed, and any differences were considered statistically significant if $p < 0.05$ **Results:** The graphs show that for both MDI drugs the normalized particle size distributions are similar for both devices



Key: Plate Number | 0 = 10 0-9 0 μm 1 = 9 0-5 8 μm 2 = 5 8-4 7μm 3 = 4 7-3 3 μm
4 = 3 3-2 1 μm 5 = 2 1-1 1 μm 6 = 1 1-0 65 μm 7 = 0.65-0 43 μm

For Proventil HFA, $p > 0.05$ for all eight plates
For Proventil MDI, $p > 0.05$ for all plates *except* for 1 ($p = 0.04$), 2 ($p = 0.006$), and 3 ($p = 0.02$)

Conclusion: The built-in nozzle in the MediSpacer introduces no preferential selection of particle sizes, relative to the manufacturer's nozzle in the AeroChamber.

OF-97-141

EVALUATION OF A BI-DIRECTIONAL MDI ACTUATOR FOR INLINE VENTILATOR DRUG DELIVERY.

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Introduction: Reservoir (spacer) devices are usually used with metered dose inhaler (MDI) aerosol drug adminstration to improve drug delivery to intubated, ventilated subjects. Purpose: The purpose of this study is to evaluate MDI aerosol drug delivery of albuterol (Proventil™) through an endotracheal tube (ETT) using a novel bi-directional actuator (Thayer/Allegiance MiniSpacer) in comparison with four other MDI actuator/reservoir devices. The MiniSpacer is a tee-type adaptor inserted in the inspiratory tubing. Methods: The MiniSpacer was compared to the DHD ACE, the Allegiance MediSpacer, the Monaghan AeroVent, and the Hudson Tee for MDI administration of albuterol, using a lung model. All devices were placed as instructed by manufacturer in the inspiratory limb of a disposable, humidified ventilatory circuit. The MiniSpacer was positioned 22 cm above the patient wye. The patient wye and a right angle adaptor were connected to an 8 0 mm ID ETT a dual chambered test lung. Ventilation was provided by an MA-1 with VT = 800 mls, rate = 10/min, and inspiratory flow = 60 L/min. Twelve MDI actuations were used to measure drug dose, which was collected at the end of the ETT on a Baxter two-way bacterial filter. The filter was washed with a 0.2 M HCl solvent buffered with phosphate, and drug amount analyzed using a Beckman DU 640 spectrophotometer at 276 nm. A total of 6 samples of each brand were tested. Results: Drug delivery at the end of the ETT is expressed as percent of the dose measured from the MDI.

	Hudson T*	MiniSpacer†	AeroVent†	MediSpacer‡	ACE‡
Mean (SE)	12.0% (0.4)	17.2% (0.5)	17.7% (1.0)	31.8% (0.7)	30.0% (0.8)
Range	11.3-13.5%	15.2-18.3%	15.2-22.1%	29.5-34.5%	28.5-34.0%

Both Kruskal-Wallis and oneway ANOVA gave a significant difference across all brands ($p < 0.005$). Follow-up comparisons using Scheffe showed a significant difference ($p < 0.05$) between brands with different superscripts (*, †, ‡). Conclusion: The new bidirectional MDI adaptor was superior to the unidirectional Hudson T adaptor in dose delivery through an ETT, and equivalent to the large-reservoir AeroVent. The tee-type adaptor does not perform as well as the large reservoir MediSpacer or ACE. Clinical differences remain to be determined.

OF-97-111

INFLUENCE OF HE:OX ON AEROSOL DELIVERY FROM A MDI AND SPACER DURING MECHANICAL VENTILATION

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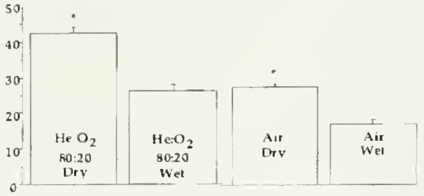
Div of Pulm and Crit Care Med, Edward Hines Jr. VA Hospital and Loyola Univ Chicago, Stritch School of Medicine, Hines IL.

Helium: oxygen ($He:O_2$) mixtures have been employed as an adjunct to decrease airway resistance and to relieve respiratory distress experienced by patient with severe airway obstruction during mechanical ventilation. The effect of $He:O_2$ on aerosol delivery to the lower respiratory tract with a MDI has not been well described. To that end, we compared aerosol delivery of albuterol from a MDI and spacer chamber during mechanical ventilation (CMV), while delivering $He:O_2$ of 80:20 and air under both dry and heated/humidified (wet) conditions to a tracheobronchial model attached to a lung simulator. A monitor (VenTrak) was used to measure volumes and flows with both gas mixtures and albuterol deposition on filters distal to the tracheobronchi model was determined by spectrophotometry. Results (below) expressed as the % of nominal dose delivered.



Delivery of albuterol was greater with 80:20 $He:O_2$ than air under both wet and dry conditions ($p<0.001$). Drug delivery was reduced with heat and humidification with both gases (*$p<0.15$). Conclusion: When a MDI and spacer chamber was employed, $He:O_2$ improved drug delivery to the bronchi compared to air during CMV.

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OF-97-176

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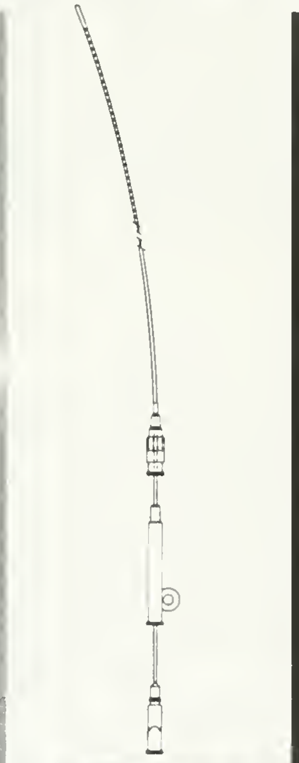

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HELIUM OXYGEN REDUCES NEBULIZER EFFICIENCY

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Patients with acute severe airway obstruction commonly require aerosolized bronchodilators for relief. Helium: oxygen (He:O_2) mixtures have been employed as an adjunct to decrease airway resistance and to relieve respiratory distress experienced by these patients. However, the effect of He:O_2 on aerosol delivery to the lower respiratory tract and pneumatic nebulizer performance has not been determined. METHOD: We compared aerosol delivery with a pneumatic nebulizer (HEART) while driven by He:O_2 of 80:20 and oxygen at a variety of flow rates. For each experiment, we administered albuterol sulfate (40 mg) with 0.9% NaCl (72 ml) for ten minutes, collecting albuterol on filters distal the nebulizer output and distal to an upper airway/lung model (TTL) which simulated spontaneous breathing. Gas flow and volumes were monitored with a pneumotach/microprocessor (VenTrak) and albuterol was measured with spectrophotometry (n=3). RESULTS: Nebulizer output (mean±SD) when operated at a flow of 10L/min was higher with O_2 (610.9±39µg) than with He:O_2 80:20 (443±59µg ; $p<0.005$), as was delivery to the lung model (95.6±8 µg, 49±22 µg, respectively; $p<0.03$). When He:O_2 80:20 flow was increased to 23 L/min, nebulizer output (590±2 µg) increased, and delivery to the lung model (289±15 µg) was greater than with O_2 at 10 L/min ($p<0.0001$). In summary, using standard operating conditions, the efficiency and drug delivery with a nebulizer was reduced when it was operated with He:O_2 instead of O_2, however, when the He:O_2 flow rate was increased by 250%, the delivery of albuterol to the lung model increased by more than two fold. CONCLUSION: He:O_2 of 80:20 is less efficient than O_2 in driving a pneumatic nebulizer at standard operating conditions.

Veterans Administration Research Service

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EFFECT OF ONE-WAY VALVES ON ALBUTEROL DELIVERY FROM A HEART NEBULIZER DURING CMV

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Patients with acute severe airway obstruction commonly require aerosolized bronchodilators for relief. Continuous nebulization of albuterol with large volume continuous nebulizers has been advocated for patients during continuous mechanical ventilation (CMV), with little available data to determine the best method of delivery. The use of a one-way valve between the nebulizer and the inspiratory limb of the ventilator circuit serves to isolate the compressible volume of the nebulizer from the ventilator, but the impact on aerosol delivery to the lung has not been described. We compared aerosol delivery with a pneumatic nebulizer (HEART) during CMV with and without a one way valve to a tracheobronchial model under dry and wet conditions. For each experiment, we administered albuterol sulfate (40 mg) with 0.9% NaCl (72 ml) from a HEART nebulizer driven with O_2 at 10L/min to a tracheobronchial model (n=3). Drug was captured on filters and measured by spectrophotometry. Delivery of albuterol to the lower respiratory tract was greater without the one-way valve in both dry (420±55(SD) µg without, 244 5±4µg with; $p<0.037$ ANOVA) and heated/humidified (wet) conditions (244.5±3µg without, 90.8±12µg with, $p<0.008$) Under wet conditions we found no difference between standard and heated wire circuits The reduction in compressible volume was < 60ml. In conclusion, when using a HEART nebulizer for continuous nebulization during mechanical ventilation, the use of a one-way valve between the nebulizer and the ventilator circuit markedly reduced delivery of drug to the lower respiratory tract.

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OF-97-178

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U.S. Patent No. 5,540,220

MOBILE VENTILATION SYSTEM FOR A PEDIATRIC PATIENT REQUIRING HIGH LEVELS OF PEEP AND CONTINUOUS FLOW : A CASE REPORT

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Introduction: Even with new homecare ventilator technology appearing in the market, achieving cost effective home care is a constant challenge We report the modification of existing homecare technology to meet the needs of a homeward bound ventilator dependent patient with a large tracheal leak who required high PEEP and mobility
Case Summary: A 3 year old female quadriplegic from C-1,C-2 fracture has severe tracheal and bronchial malacia which contributed to a left lower lobectomy and large air leak around the tracheotomy tube (further exacerbated during sleep and unresolved by changing size, brand or cuff style) During the acute care stay of almost 1 year, conventional volume ventilation failed due to loss of PEEP during the expiratory phase, but pressure ventilation was successful To mimic constant flow and leak compensation while providing portable volume ventilation, we combined a PLV-100 (Lifecare) and a Remstar CPAP generator (Respironics) to create a closed IMV system The CPAP generator is introduced into the circuit at the PLV-100 patient air outlet using a one-way valve, preceding the bacteria filter and cascade 1a humidifier The CPAP generator pressure level is set at the same level as the external PEEP valve and may be titrated to assure consistent PEEP and flow A pressure relief valve prevents inadvertent high pressures, water traps and hydrofilters manage the rainout A low pressure alarm was placed in line and set 1 cmH_20 below the prescribed PEEP level The ordered settings were as follows Vt 150ml, Mode IMV, Rate 24, F_I0_2 .21, PEEP +10 cmH_20 The patient's secretions remained unchanged between the mobile and traditional ventilation systems Performance of the ventilator and alarms were not altered by the additional flow Pressure waveform analysis of this system was compared against the PLV-100 alone and no difference could be distinguished Exhaled V_t monitoring consistently revealed V_t between 150 and 200ml. The system was trailed for several months in ICU and rehabilitation hospital settings prior to discharge The system was mounted on a wheelchair tray, equipped with manufacturers' adapters and powered by 12 volt battery. Family training occurred on this system and emergency procedures over a period of several months and the patient was discharged. The patient has been successfully managed at home for over 6 months with this system No adverse events have occurred and the patient's pulmonologist states the patient is thriving
Discussion: Our experience demonstrates that the use of volume ventilation in conjunction with a CPAP generator creates a closed IMV ventilation system capable of providing high levels of PEEP, leak compensation and portability for the ventilator dependent pediatric patient Continued work in the area of using volume control on inspiration and pressure control on expiration may help develop a standardized protocol for integrating an external continuous flow source with conventional portable volume ventilation.

OF-97-006

OXYGEN DELIVERY THROUGH PORTABLE VENTILATORS
A COMPARISON OF FOUR METHODS

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Background: Patients receiving home mechanical ventilation often use supplemental oxygen There are several methods used for delivering oxygen to a portable ventilator I set out to determine the most efficient method for delivery oxygen to patients **Method:** An LP-10 (Aequitron, Inc. Minneapolis, MN) was connected to a test lung An oxygen analyzer (Hudson, Inc Temecula, CA) was placed in the ventilator circuit (Allegiance, Round Lake, Il) at the circuit wye The ventilator was set at tidal volumes of 100, 200, 300, 400, and 500 cc. The rate was set at 6, 10, 15, and 20 breaths per minute with an inspiratory time of 1 second Oxygen was delivered using four different methods 1) a line adapter (Hudson) was attached to the air entrainment port of the ventilator, 2) a line adapter (Hudson) was attached to the ventilator outlet port, 3) an IMV bag was connected to the ventilator outlet port, and 4) a side-port connector (Bivona, Inc. Gary, IN) was placed at the circuit wye The analyzer was used to measure the FiO_2 when 1 lpm of oxygen was delivered using each oxygen delivery method at each variation in ventilator settings The bench test was run four times using two different ventilators **Results:** In all four delivery methods, the FIO_2 was higher at lower ventilator settings. As tidal volumes and rates were increased, the FiO_2 decreased There were differences in FiO_2 levels based on the delivery method used When oxygen was introduced using either the IMV bag or the adapter at the outlet port, concentrations were consistently higher throughout all ventilator settings When oxygen was introduced through the air entrainment port or at the circuit wye, the lowest oxygen concentrations were detected **Experience:** In portable ventilation, the FiO_2 values are expected to decrease as minute ventilation increases This is because the room air that is generated by the ventilator will increase with increases in minute ventilation The FiO_2 relies on the both the minute ventilation produced by the portable ventilator and the flow rate of oxygen To provide the most efficient delivery of oxygen to patients, those methods which require the lowest flow rates of gas should be utilized These methods will also prove to be the most cost effective **Conclusion:** Based on the above tests, the most efficient and cost effective method for delivering oxygen to a portable ventilator is accomplished by introducing the oxygen at the ventilator outlet port using a line adapter or through an IMV bag

Table 1
FiO2 Analyzed

	Volume 100 cc				Volume 200 cc				Volume 300 cc				Volume 400 cc				Volume 500 cc			
	Delivery Method*																			
Rate	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
6	47	59	70	44	42	69	65	37	37	63	72	30	32	65	69	30	31	57	60	27
10	39	59	65	41	39	39	46	33	35	48	46	29	31	48	50	27	30	39	44	26
15	48	61	63	35	38	39	38	31	34	38	36	28	30	37	39	26	29	34	34	25
20	42	49	54	34	36	34	35	29	33	34	33	27	29	33	34	25	28	31	32	24

*Delivery Methods 1 = Line adapter at air entrainment port, 2=Line adapter at air outlet port, 3=IMV bag at air outlet port, and 4=connector at circuit wye

OF-97-024

HELIUM-OXYGEN (HELIOX) VIA THE SERVO 900C TO MECHANICALLY VENTILATE THE STATUS ASTHMATICUS PATIENT

Linda Dean RRT & Dwayne Smith RRT RPFT. Fairfax Hospital, Falls Church, Virginia

OBJECTIVE. To examine the effects of heliox to mechanically ventilate the acute status asthmaticus patient who fails conventional ventilation
DESIGN Retrospective case series of 6 status asthma patients who failed the first hr of conventional ventilation, then placed on heliox via Servo 900C
METHODS. Conventional settings were placed on the Servo. 50 psi O_2 hose was connected to the O_2 outlet, 50 psi air hose connected to the 50 psi port on the 8/20 Heliox mixture H cylinder, giving the blender its 2 gas sources. A 70/30 mixture was our goal An O_2 analyzer on the insp. limb confirmed FiO_2, and a Wright's respirometer (calibrated for heliox) confirmed exhaled Vt
RESULTS Our findings reveal positive outcomes. Overall, within the first 30 minutes, the PIP decrease was clinically significant, but our sample was too small for adequate statistical power $PaCO_2$ decreased significantly [mean (±SD)] from 62.2 (7 6) mm Hg to 39 6(8.5) mm Hg, p=0 02. pH increased from 7 17 (0.01) units to 7.33 (0 07) units, p=0 01. FiO_2 was decreased from 66(21)% to 24(12)%, p=0.01. Auto-PEEP recorded in 1 patient decreased from 16 cm H_2O to 8 cm H_2O No patients required chest tubes secondary to barotrauma, and all patients were weaned from the ventilator upon reversal of bronchospasm There were no untoward effects
CONCLUSION Heliox mixtures may be implemented immediately to mechanically ventilate the status asthma patient to facilitate $PaCO_2$ reduction, reverse resp acidosis, lower PIP, lower FiO_2, and decrease risk of barotrauma

OF-97-020

EVALUATION OF WATER ACCUMULATION IN THE HEALTHSCAN OPTIVENT™, DHD ACE®, MONAGHAN AERO VENT® METERED DOSE INHALER SPACERS UNDER NORMAL MECHANICAL VENTILATION CONDITIONS.

Jonathan B. Waugh, Ph.D., RRT, John B. Waugh, BA, Joseph L. Rau, Jr., Ph.D., RRT
Cardiopulmonary Care Sciences Department, GA State University, Atlanta, GA

Introduction. Clinicians attempt to minimize contamination of a patient's airways by reducing the frequency of opening the ventilator circuit. Metered dose inhaler (MDI) spacers are now designed to be left in the ventilator circuit between drug administrations, which raises the question, how much fluid accumulates and is it a safety concern?
Methods: We measured distilled water accumulation in three brands of MDI spacers (OptiVent, ACE, AeroVent) at 0, 30, and 45 degree positions at 4 and 8 hour time intervals. Water accumulation was measured by the difference in Pre-test (dry) weight and post-test (wet) weight, using the same ventilator, circuit, humidifier (Fisher & Paykel MR480), and test lung with a room temperature range of 71-73° F and relative humidity range of 59-63%.
Results:

Spacer Brand	Position (degrees)	Grams of Water Increase at:	
		4 Hours	8 Hours
OptiVent	0	4.641	9.520
AeroVent	0	1.046	1.079
ACE	0	10.570	23.141
OptiVent	30	1.782	1.785
AeroVent	30	0.673	0.825
ACE	30	6.503	8.049
OptiVent	45	1.582	1.578
AeroVent	45	0.598	0.681
ACE	45	5.300	6.561

Conclusions. In the angled positions, both the OptiVent and AeroVent spacers accumulated "clinically" insignificant amounts of fluid over both 4 and 8 hour periods of use (less than 5 ml). All three spacers can be left in line with ventilated subjects however the OptiVent and ACE did not require manipulation to open the chamber in order to be used with an MDI canister. Determining if infection rates are influenced by leaving spacers in line or removing them between treatments would be a useful next step in the investigation of these devices.

OF-97-065

ISOFLURANE ADMINISTRATION VIA A SERVO 900C VENTILATOR FOR SEDATION OF A SIX MONTH OLD INFANT IN THE POST OPERATIVE PERIOD Suzanne M Durning, BA, RRT, P/P Spec , Linda A Napoli, BS, RRT, RPFT, P/P Spec , Theresa R Schultz, BA, RRT, CPFT, P/P Spec., R I Godinez, MD PhD, The Children's Hospital of Philadelphia, Philadelphia, PA

Published data on the prolonged use of isoflurane in post-operative patients is available, although reports of pediatric application are limited A 6 month old, 7 2 kg infant, born at 36 weeks gestational age, was referred to our institution for management of impending respiratory failure due to RSV bronchiolitis She required intubation and ventilation for 7 days After failed extubation attempts, a bronchospcopy was performed and revealed a subglottic tracheal cyst The cyst was resected and, following a normal post-operative cuurse, the patient was returned to the referring institution in order to be closer to home After 12 days at the outlying hospital, she began to develop respiratory distress She was again transferred to our institution and a broncheospy revealed cricoid narrowing The patient was treated with a cricoid split Post surgery, adequate sedation was not achieved despite the use of maximom levels of intravenous drugs Sedation was an important issue due to the critical nature of the airway and the anticipated need for a prolonged sedation period (7 - 10 days in accordance with normal practice following a cricoid split) The patient was placed on isoflurane in an attempt to successfully manage the sedation level The isoflurane was administered in the Pediatric Intensive Care Unit, via a Servo 900C with a Siemens Vaporizer 952, and Servo Manual Ventilation Accessory 963 The Servo Evac 180 was used for gas scavenging Level of sedation was determined, and titration of isoflurane was performed, by an anesthesiologist/ critical care physician Environmental testing with an infrared spectrophotometer and dosimeter assured proper function of the system Serum fluoride levels of 0 1-0 3 mg/dL are within normal limits No abnormalities were noted in mean inorganic fluoride concentration or serum creatinine levels Hemodynamic status remained stable on isoflurane levels ≤0 9% After 7 days, the isoflurane was discontinued with a rapid return of the patient to a wakeful state The patient's natural airway was deemed to be adequate and she was successfully extubated She was discharged 18 days after this admission

Conclusion: In this patient, isoflurane administration provided a safe, effective and reliable method of sedation management

OF-97-068

DURATION OF FLOW AND ACCURACY OF TIDAL VOLUME DELIVERY WHEN USING "D" CYLINDERS AS THE MAIN GAS SOURCE FOR THE BIRD AVIAN TRANSPORT VENTILATOR. JIMMY P CREDO, RRT, RPFT and DAVID C SHELLEDY, PhD, RRT, RPFT, The University of Health Science Center at San Antonio, San Antonio, Texas

BACKGROUND: Ventilator dependent patients may be transported using small oxygen cylinders. Knowledge of the duration of flow available from the cylinder at a given minute ventilation is needed to assure that a sufficient amount of time is available during transport Traditionally, a standardized formula has been used to estimate duration of available flow D cylinder flow duration (min) = [(0 16 x gauge pressure)/minute volume]) We sought to determine the actual duration of flow available when using "D" oxygen cylinders as a main gas source to power the Bird Avian Transport Ventilator (Bird Products Corp , Palm Springs, CA) The effect of decreasing cylinder pressure on delivered tidal volume was also evaluated **METHOD:** Five Bird Avian Transport ventilators were used in the study Functional checks as specified by the manufacturer were performed on each ventilator The ventilators were connected to full "D" oxygen cylinders as the main gas source. Ventilator parameters were set as follows V_T 800 ml, frequency 12 BPM, V_E 9 6 L/min, inspiratory flow 50 L/min Each ventilator was run continuously until the cylinder was empty This was repeated for a total of three trials per ventilator For each 100 psig cylinder pressure change, the expired tidal volume was measured using a Wright Respirometer **RESULTS:** The mean duration of flow for the three trials for each of the five ventilators is listed below:

	v1	v2	v3	v4	v5
Mean (SD) Exp Vol	805 35 (3 43)	852 81 (7 01)	829 47 (1.90)	875 26 (2 93)	840.87 (3.00)
Mean (SD) duration of flow (min.)	31 47 (1 91)	31 08 (2 00)	32 98 (0.51)	30.30 (0 45)	32 47 (1 51)

The mean duration of flow for all trials for the five ventilators was 32 10 minutes (SD 1.51 min) This compared to a calculated available flow of 36 67 minutes The mean expired tidal volumes of the five ventilators was 834 89 ml (SD = 22 71) There was no drop in delivered tidal volume until the cylinder pressures were below 250 psig **CONCLUSIONS** The Bird Avian Transport Ventilators delivered consistent tidal volumes until cylinder pressure was less than 250 psig Duration of available flow was from 4-6 minutes less than the estimate provided using a standard formula Our study suggests that "D" oxygen cylinders can be use effectively with the Bird Avian Transport Ventilator to transport ventilator dependent patients We recommend that cylinders be changed when the cylinder pressure drops to approximately 250 psig to insure gas flow is not interrupted and to maintain adequate tidal volume delivery We further recommend that the standard duration of flow calculation be used cautiously, as it may overestimate the time available for patient transport.

OF-97-090

EVALUATION OF THE IMPACT 754 PORTABLE VENTILATOR. Robert Campbell RRT, Jay Johannigmao MD, Kenneth Davis Jr., MD, Richard D Branson RRT Department of Surgery, University of Cincinnati, Cincinnati, OH

Background: Transport of the mechanically ventilated patient can be aided by use of a transport ventilator We evaluated the Impact 754 in the laboratory and during transport of mechanically ventilated patients from the ICU. The 754 has an integral compressor, blender, and PEEP control. **Method:** Tidal volume (V_T) delivery and FIO_2 stability were measured during simulated ventilatory support of a lung model at V_T's of 250, 500, 750, and 1000 ml., PEEP of 0-10 cm H_2O, FIO_2 of 0.21, 0.5 and 1 0, respiratory frequency of 10-20 b/min, and varying compliance and resistance settings (compliance 0.02-0.1 L/cm H_2O, resistance 5-20 cm H_2O/L/s) Volume measurements were made using integral test lung software (PneuView, Michigan Instruments). Airway pressures were measured with standard physiologic transducers and FIO_2 was measured with a precision analyzer (OM-11, Sensormedics, Inc) Twelve patients requiring transport from the ICU had ABG's measured prior to transport (PB 7200ae) and after transport (Impact 754). Ventilator settings were matched for V_T, FIO_2, PEEP, and *f* **Results:** Tables 1 and 2 show laboratory and clinical findings respectively Data were analyzed using a t-test, ($^*p<0.05$).

Table 1 Set V_T/FIO_2	C_L=0.1, Raw=5		C_L=0.02, Raw=5		C_L=0.02, Raw=20	
	V_T(mL)	FIO_2(%)	V_T(mL)	FIO_2(%)	V_T(mL)	FIO_2(%)
250 mL/0.5	247(12)	47(3)	230(10)	48(3)	213(16)*	47(2)
500 mL/0.5	509(21)	46(4)	471 (32)	53(2)	440(16)*	52(4)
1000mL/0.5	1056(40)	48(4)	945 (34)	50(3)	815(15)*	54(3)

Table 2	Nellcor PB 7200ae	Impact 754
pH	7.37 (0.08)	7 35 (0 1)
$PaCO_2$	45 (4)	44(5)
PaO_2	84 (17)	88 (13)

Average duration of transport was 75 (22)mins Mean PEEP was 9(3) cm H_2O and mean FIO_2 was 48(8). **Conclusions:** Delivered V_T diminished as peak pressure increased and compressible volume of the circuit increased The decrement in V_T was significant at C_L=0 02, Raw=20 FIO_2 was stable at all settings tested Patients tolerated transport and there were no adverse events. There were no significant differences in blood gases between the ICU ventilator (7200ae) and Impact 754 The Impact 754 provides adequate ventilation and oxygenation during transport of ICU patients and provides an adjustable FIO_2.

OF-97-130

LABORATORY EVALUATION OF THE PRESSURE AND VOLUME DELIVERY OF THE INTRAPULMONARY PERCUSSIVE VENTILATOR (IPV).

Robert S Campbell RRT, James J Lawson* RRT Richard D Branson RRT Jay A Johannigman MD, Fred A Luchette MD, Kenneth Davis Jr MD Department of Surgery, University of Cincinnati Medical Center, Cincinnati, OH, * Respiratory Care Department, Kettering Medical Center, Kettering, OH

BACKGROUND The Intrapulmonary Percussive Ventilator (IPV) (Percussionaire Corp) is a pneumatic positive pressure device used to enhance secretion clearance and recruit lung volume IPV utilizes a sliding venturi to create a percussive (pulsatile) flow waveform at a frequency between 100 and 240 cycles per minute at driving pressures (DP) of 20 to 50 psig We evaluated the pressure and volume delivery of the IPV in a lung model **METHOD** An IPV was powered with 50 psig source gas and connected to one chamber of test lung (TTL, Michigan Instruments) via a simulated trachea (imatrach, Mallinckrodt). TTL settings included compliance (C) of 0 03 and 0 06 L/cmH_2O and resistance (R)of 5 and 20 cmH_2O/L/sec. The DP of the IPV was set to 30, 40, and 50 psig with "percussion" set at 50% of the scope of the control Pressure was measured proximal to the trachea and within the test lung and volume was integrated from the flow signal measured between the trachea and test lung using a Fleisch pneumotach Peak lung pressure pressure amplitude in the proximal airway time (T) to attain a pressure equilibrium in the lung, and tidal volume (V_T) were measured and recorded Breaths were manually actuated for 10 seconds and 5 breaths at each setting were averaged P and V_T at each DP were compared using ANOVA, p<0.05 was considered significant **RESULTS** Table 1 reveals the P T to pressure equilibration, and V_T at C (0 03) and R (20) at each DP tested Mean pressure amplitude in the proximal airway was 40 3, 28 7, and 23 4 cmH_2O with DP of 50, 40, and 30 psig respectively

Table 1

	50 psig	40 psig	30 psig
P (cmH_2O)	21.3 ± 1.3	16 1 ± 1.2*	10.0 ± 1.1*#
T to equil (sec)	5.9 ± 0 5	5.1 ± 0 4	3 7 ± 0 3*#
V_T (mL)	750 ± 46	536 ± 34*	323 ± 31*#

*=p<0 05 vs 50 psig, # =p<0.05 vs 40 psig

CONCLUSION Pressure delivery to the lung during IPV is within a safe and clinically acceptable range at all DP tested. Delivered V_T is dependent on set DP and lung C and varies only slightly with changing R T to pressure equilibrium increases as R, DP and C increase Actuation times of greater than 5 seconds are recommended to attain maximal volume recruitment.

OF-97-131

COMPARISON OF THE PRESSURE (P) AND TIDAL VOLUME (V_T) DELIVERY OF TWO INTRAPULMONARY PERCUSSION VENTILATORS (IPV) HOME UNIT VS HOSPITAL UNIT

James J. Lawson* RRT, Robert S Campbell RRT, Richard D Branson RRT, Jay A Johannigman MD, Fred A Luchette MD, Kenneth Davis Jr MD Department of Surgery, University of Cincinnati Medical Center, Cincinnati, OH, * Respiratory Care Department, Kettering Medical Center, Kettering, OH.

INTRODUCTION IPV (Percussionaire Corp) is a pneumatic positive pressure device used to enhance secretion clearance and recruit lung volume IPV utilizes a sliding venturi to create a percussive flow waveform at a frequency between 100 and 240 cycles per minute at driving pressures (DP) of 20 to 50 psig Two models are currently available: 1) home unit powered by compressor, and 2) hospital unit powered by 50 psig source gas We compared P and V_T delivered from each IPV in a lung model **METHOD** Each IPV was attached to one chamber of test lung (TTL, Michigan Instruments) via a simulated trachea (imatrach, Mallinckrodt Medical) TTL settings included compliance (C) of 0.03 and 0.06 L/cmH_2O and resistance (R) of 5 and 20 cmH_2O/L/sec DP of each IPV was set to 30 40, and 50 psig with "percussion" set at 50% of the scope of the control P was measured proximal to the trachea and within the TTL V_T was integrated from the flow signal measured with a Fleisch pneumotach. Peak lung P, time (T) to attain a P equilibrium (EQ) in the lung, and V_T were measured and recorded Five breaths were manually actuated for 10 seconds and at each setting, were recorded and averaged P and V_T results were compared for each IPV unit using t-test, $p < 0.05$ was considered significant **RESULTS** Table 1 reveals V_T and T to P EQ for home and hospital IPV at each C and R with 50 psig DP Table 2 reveals mean lung P and V_T delivery by home and hospital IPV at 30, 40, and 50 psig DP(C=0.03,R=20).

Table 1

	UNIT	C=0.06,R=5	C=0.03,R=5	C=0.06,R=20	C=0.06,R=20
V_T (mL)	Hosp	1199 ± 48	643 ± 34	1225 ± 62	750 ± 38
V_T (mL)	Home	656 ± 30*	331 ± 24*	629 ± 29*	432 ± 24*
T - EQ (s)	Hosp	5.5 ± 0.4	3.9 ± 0.3	6.8 ± 0.5	5.9 ± 0.4
T - EQ (s)	Home	4.3 ± 0.3	3.1 ± 0.3	5.5 ± 0.4	3.3 ± 0.3

Table 2

	UNIT	30 psig	40 psig	50 psig
V_T (mL)	Hospital	323 ± 22	536 ± 26	750 ± 38
V_T (mL)	Home	206 ± 19*	285 ± 20*	432 ± 24*
Lung P (cmH_2O)	Hospital	10 ± 0.9	16.1 ± 1.1	21.3 ± 1.3
Lung P (cmH_2O)	Home	8.9 ± 0.8	12.1 ± 0.9*	13.7 ± 1.1*

* = $p<0.05$ home IPV vs hospital IPV

Delivered V_T and lung P were lower with the home IPV at all settings **CONCLUSION** P and V_T varies between the home and hospital IPV The difference in P and V_T are accentuated at high DP

OF-97-132

TIDAL VOLUME DELIVERY VARIABILITY FOR THREE NONINVASIVE BILEVEL POSITIVE PRESSURE (BPP) DEVICES

Bliss P, Adams A Healthpartners-St Paul Ramsey Medical Center, St. Paul, MN

Background: The use of noninvasive ventilation has been described and recommended for avoiding intubation in the settings of impending respiratory failure, assisting in the weaning process and providing ventilatory support for chronic respiratory failure. Several devices are available for non-invasive ventilation featuring simplified controls and at less cost than critical care ventilators While differences between critical care ventilators exist, the gas delivery characteristics at their standard settings is considered precise and predictable between ventilators We evaluated 3 BPP devices at similar settings to determine variability in tidal volume (VT) delivery between and within devices **Methods:** The BPP devices (Nellcor-Puritan Bennett 335 (NPB), BIPAP STD, Healthdyne Quantum) were sequentially tested on one lung of a Michigan lung model system (Grand Rapids, MI) at IPAP = 15 cmH2O, EPAP = 3 cmH2O and various available trigger and rise time settings A ventilator driving the other lung triggered efforts by a lift arm An open, fixed orifice was interposed to simulate a leaking mask. Flow was measured by a Hans-Rudolph pneumotach and Validyne MP-45 transducer. Data was acquired and flow was integrated to attain VT measurements from 10 breaths by LabTech software (National Instruments). **Results:** Differences in VT between and within devices are shown below

Device and settings	Max	Min	Average	S. D.	C. V.
NPB 335 1/1 (insp/exp trigger)	842	666	774	50	6.4%
NPB 335 3/3 (insp/exp trigger)	920	895	909	9	0.9%
BiPAP STD	890	877	885	4	0.5%
Quantum .1 rise time	499	459	485	11	2.2%
Quantum .5 rise time	609	591	603	6	1.0%
Quantum .9 rise time	678	631	650	14	2.2%

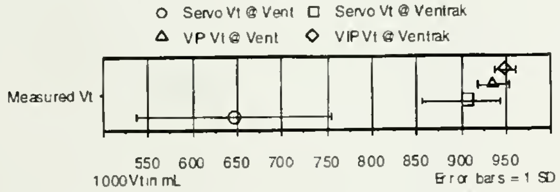
At the same general settings VT delivery varied between devices **and** in the same device at different trigger or rise time settings Variability for a device at the same setting was minimal as noted by low coefficients of variation. The patterns of flow delivery differed, visually, between and within devices according to trigger and rise time differences **Conclusions:** To assure comparable performance between devices a practitioner must be aware of the level and meaning of trigger and rise time settings Even when adjustments are made, it may be difficult to substitute devices to accomplish precisely the same task Performance characteristics varied between and within devices in this lung model study, however, we can not comment on the ability of BPP devices to meet specific intended clinical purposes. Supported by the Ramsey Foundation.

OF-97-138

COMPARING VENTILATOR TIDAL VOLUME DELIVERY AND MEASUREMENT IN TWO BRANDS OF MECHANICAL VENTILATORS.

Jim Keenan BS, RRT, John Salyer BS, RRT, Keylene Christensen RRT, Stephanie Jemmett RRT. Primary Children's Medical Center, Salt Lake City, Utah.

Introduction: We sought to determine if there were differences in the delivery and measurement of Vt in two brands of ventilators. **Methods** Servo 900 C (n=9) and Bird V.I.P. ventilators (n=16) were tested from our working fleet. All were functioning normally, maintained and calibrated according to manufacturer's guidelines. Testing was done in a volume-limited mode with a set Vt of 1000 mL, while ventilating a Michigan TTL test lung with the compliance set at = 0.010 L/cm. A 2 ft tygon test circuit was used to minimize compressible volume loss A leak check was performed on the entire system before each run. Vt was recorded after two minutes from the intrinsic measurement mechanism of each ventilator and by a computerized pneumotachograph at the airway opening (Ventrak). Accuracy of the Ventrak was verified using 100 and 1000 mL Hans Rudolph calibration syringes. Differences in Vt measurements were tested for statistical significance (P<0.05) using ANOVA. **Results:** For the Servo ventilators we found statistically significant differences in Vt between the ventilator's measurement system and the Vt reported from the Ventrak Conversely, the differences between the Vt's measured by the VIP and by the Ventrak were not statistically significant. There were also statistically significant differences in Vt measured by the Ventrak when comparing the 900 C and VIP.



Discussion: Our data suggests that the performance of the intrinsic Vt measuring system of the 900 C ventilators is very poor when compared to the VIP ventilators. Assuming the Ventrak readings to be the true Vt, it is also clear that the VIP ventilators deliver a larger Vt than the 900 C under large Vt and poor compliance conditions, although this difference may not be clinically important

OF-97-160

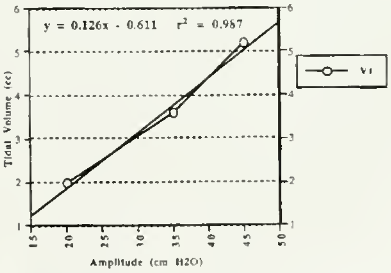
TIDAL VOLUME DELIVERY OF A PROTOTYPE INFANT HFV DEVICE.

Kelvin D MacDonald, RRT, Peter B Wang, RRT, Kaiser Permanente Medical Center, Los Angeles. Dennis L Vinson, RCP Childrens Hospital, Los Angeles.

Introduction: The Infrasonics Infant Star High Frequency Ventilator has a fixed inspiratory time of 18 msecs during HF ventilation A new prototype model (950+) of the Infant Star features adjustable inspiratory times of 5 msec increments from 10 to 50 msec We evaluated this new prototype to see the effect of varying inspiratory time on delivered Vt during HFV of a test lung. Using a precision (+/- 8%) system with a known underestimation bias (Monaco F, et al. 1993 AARC Conf. Open Forum), we sought to measure delivered Vt across a range of amplitude settings with different HFV inspiratory times. **Methods:** A prototype Nellcor-Puritan Bennett Infant Star 950+ was tested following calibration to factory standards. The device was attached to a 1.0 ml/cm H20 dynamic lung model (Michigan Inst., MI) with a 12 cm long, 3.5 mm I.D. ETT. A hot-wire anemometer ([NVM-1]Allied Medical, Riverside, CA) and pressure line were placed at the proximal wye and interfaced to a Novametrix Ventrak (Wallingford, CT) monitoring system. Frequency, Vt, and amplitude were captured and averaged for a three minute sample by IBM compatible PC. MAP was held at 30 cm H20, with the I.T adjusted to 20, 35 and 45 msec for the prototype. Values for Vt were recorded at 10 Hz frequency , at the range of amplitude shown in the following tables:

950+	12 cm	20 cm	40 cm	60 cm	80 cm
(20 msec)	0.8 cc	1.3 cc	2.0 cc	2.3 cc	3.3 cc
(35 msec)	1.4 cc	2.2 cc	3.6 cc	4.0 cc	5.8 cc
(45 msec)	2.0 cc	3.4 cc	5.2 cc	6.4 cc	9.1 cc

Vt as Insp. Time Increases @ 40 cm H2O Amp.



A plot of Vt with increasing I.T. shown above demonstrates the near linear (r2=.987) increase in Vt as I.T. is increased. This pattern was seen at all levels of amplitude tested. **Conclusion:** While measurements of delivered volume in our model cannot indicate clinical effectiveness, our experience suggests the prototype offers significant performance and range of Vt when compared to previous models of the Infant Star HFV. Further development and clinical trials seem warranted.

OF-97-161

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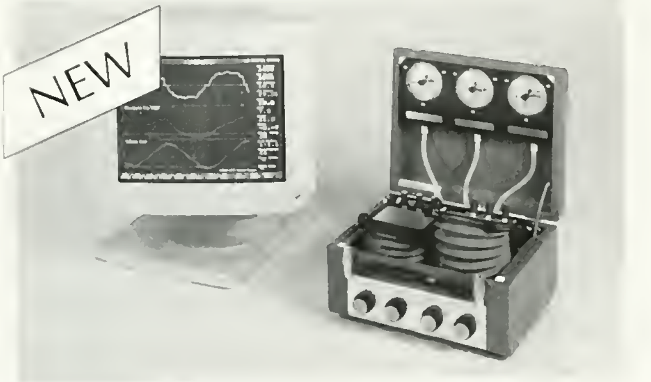

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COMPARISON OF IMPOSED WORK OF BREATHING BETWEEN CONSTANT FLOW AND FLOW ASSIST DURING SPONTANEOUS BREATHS WITH THE NEWPORT E100m VENTILATOR

V Whyte, RCP, T. Malinowski, RCP M Terry, RCP P M Gold, MD Loma Linda University Medical Center, Loma Linda, CA

Objective Determine the effect of Flow Assist (FA) on imposed inspiratory work of breathing (WOB) and compare this effect with constant flow in spontaneously breathing intubated adults requiring ventilatory support. Design Crossover study, each subject acting as their own control Method We studied 17 adult cardiothoracic surgery patients The data from 6 patients were excluded due to mechanical problems The remaining patients were ventilated in SIMV or CPAP mode Post-operative ventilatory support time prior to study ranged from 30 minutes to 8 hours Patients were stabilized on an E100m ventilator (Newport Medical Instruments) equipped with a disposable ventilator circuit (Hudson RCI) and hygroscopic condensation humidifier (HCH, Vital Signs, Inc.) Flow and airway pressure sensors were placed in-line between the HCH and the endotracheal tube Ventilator settings were appropriate for age and respiratory condition Patients were initially supported with constant flow delivery Baseline data on WOB and patient work was collected FA was activated and data collection repeated Trigger level was 1- 2 cm H_2O below baseline throughout the study During constant flow spontaneous flow was kept at 8 L/min (pre-set) and supplemental Flow was added to minimize reservoir bag deflation during spontaneous breaths (range 4 - 10 L/min). During FA, spontaneous flow was zero and supplemental flow was unchanged FA time ranged from 0.4 to 0.7 seconds Data Collection WOB and patient work were measured using the VenTrak Respiratory Monitor (Novametrix, Inc.) Respiratory mechanics were measured for 5 minutes for each flow method Ten representative breaths were selected for analysis during each flow period Analysis Plus software (Novametrix Inc.) was used for computation and data analysis Results: Results reflect the cumulative data for 11 patients A comparison was made between standard flow delivery and FA via two-way analysis of variance with replication (ANOVA) FA decreased WOB and Patient Work significantly (mean values ± SD) $p<0.01$

Work of Breathing (gm-cm/liter)		Patient Work (gm-cm/liter)	
FA off	FA on	FA off	FA on
0.1888 ± 0.12	0.0321 ± 0.27	0.4273 ± 0.43	0.1548 ± 0.17

Discussion FA uses the ventilator's set inspiratory flowrate (Mandatory flow control) to deliver gas during the inspiratory phase of a spontaneous breath FA is delivered through a open exhalation valve while maintaining CPAP Consequently much higher flow is available to the patient. Our analysis demonstrates both a statistically significant decrease in WOB (83%) and Patient Work (64%) with the use of FA Considerable breath-to-breath variations in work indices exist for each subject, probably due to differences in inspiratory effort, comfort, sedation, accounting for the large standard deviation The breath-to-breath variation in work indices was similar whether FA was on or off, both for individual subjects, and for between-subject comparisons Conclusion. The imposed WOB is less with FA than constant flow delivery during spontaneous breathing on the Newport E100m ventilator

OF-97-163

THE EFFECTS OF HELIUM-OXYGEN MIXTURES IN PEDIATRIC PATIENTS IN STATUS ASTHMATICUS REQUIRING MECHANICAL VENTILATION.

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Loma Linda University Children's Hospital, Loma Linda, California 92354.

Introduction: Patients in severe status asthmaticus (SA) may require continuous mechanical ventilation (CMV) for life threatening ventilatory failure. Mechanically ventilated patients in SA are at risk of air-trapping, elevated peak inspiratory pressures (PIP), prolonged expiratory phase, auto-PEEP, and barotrauma Low density helium-oxygen (HO) gas mixtures have been advocated to aid ventilation in patients with airway obstruction Little has been published on the use of HO in mechanically ventilated patients in SA Study Objective: This study was designed to examine the effects of HO on ventilatory parameters and blood gas indices in CMV patients in SA **Methodology:** Fifteen patients in SA requiring CMV admitted to our pediatric intensive care unit between September 1994 and May 1997 were enrolled in this study Patients were stabilized on CMV, bronchodilators, corticosteroids and antibiotics as indicated Hypercapnea was permitted, keeping the arterial blood pH ≥ 7.30 Arterial blood gas and PIP measurements were taken prior to being placed on HO and immediately after Helium and oxygen were connected via a wye and attached to the low pressure inlet of the Servo 900C Helium and oxygen flows were titrated to maintain the desired FIO_2. The group's FIO_2 ranged from .30 to .50, FIHe ranged from .50 to .70. Ventilator settings were not changed between pre and post measurements. Clinically, mechanical tidal volumes were not corrected for the decreased density of the gas. A correction factor for tidal volume (Kirmse et. al, Respir Care 1996;41(10): 954) was utilized to compare minute ventilation (V_E) retrospectively. **Results:** HO resulted in a statistically and clinically significant improvement in ventilation indices (PCO_2, pH) ($p<0.05$). PIP was reduced by a statistically significant amount ($p<0.05$) Despite no mechanical rate changes, V_E increased by 20% when corrected for the lower density HO; but this was not considered statistically significant ($p=0.07$).

Parameter	**PCO_2 - mm Hg**	**pH**	**PIP - cm H_2O**	**V_E - liters**
Pre HO	65.1 ± 24.3	7.26 ± 0.14	39.2 ± 6.8	3.77 ± 1.1
Post HO	52.1 ± 20.1	7.36 ± 0.13	33.4 ± 5.1	4.58 ± 1.4

± Standard deviation

Conclusions: 1) HO mixtures increase ventilation 2) HO mixtures may reduce the elevated PIP typically associated with SA

OF-97-164

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Abstracts & Poster Presentations

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Special consideration will be given to abstracts and poster presentations that deal with current educational trends.

The 1998 Summer Forum, scheduled for July 17–19 in Naples, FL, will offer two opportunities for participants to share their scholarly activities with colleagues:

1 Research abstract presentations dealing with respiratory care education. (Paper presentations will be limited to 15 minutes, including five minutes for discussion.)

2 Poster presentations dealing with education models, methods, or materials that can be shared for noncommercial use. (Individual topics and presenters will be briefly introduced; additional time will be allowed for individual review of posters or display materials and interaction with the presenters.)

Research abstracts and poster presentation proposals must be submitted by April 1, 1998, for review by the Education Section Review Committee. All abstracts and proposals will be peer-reviewed, and authors will be notified of decisions by May 15. Questions may be directed to the review committee chair, Pat Munzer.

Proposals must include three components:

1. Cover sheet that includes the following information:
   - a. Type of presentation (research abstract or poster presentation)
   - b. Title of presentation
   - c. Names, primary titles, work addresses, and day telephone numbers of the authors; the name of the author who will present the paper and receive correspondence should be listed first
   - d. A statement of previous presentations or publications of the same or similar work
   - **e. Two true/false questions with answers**
   - f. Other information required by funding sources
2. Camera-ready copy (without author identification) for review by the committee
3. Camera-ready original (with author identification) for possible publication

Research Abstracts

Type abstract double-spaced on plain white paper with one-inch margins. The abstract should be written as a single paragraph and limited to 300 words. The research abstract should include the following:

- a. Title of paper
- b. Brief description of work
- c. Brief statement of methodology and findings
- d. Conclusions
- **e. Two true/false questions with answers**

A maximum of two pages of camera-ready charts and tables may be attached to aid in the selection of the abstract.

Poster Presentations

Type abstract double-spaced on plain white paper with one-inch margins. The abstract should be written as a single paragraph and limited to 150 words. The poster presentation abstract should include the following:

- a. Title of paper
- b. Brief description of the model, method, or material
- c. Brief statement of how it was developed and implemented
- d. Brief statement of how it was evaluated or judged to be of unique value
- e. Recommendations for future application
- **f. Two true/false questions with answers**

On a separate sheet, describe how the information will be visually presented at the conference. Each manuscript should be double-checked for completeness and accuracy before it is submitted. Spell out terms used for the first time, followed by abbreviations in parentheses, e.g., norm-referenced testing (NRT). Thereafter, the term may be abbreviated throughout the page.

Please send the abstract and cover sheet to:

Pat Munzer, MS, RRT
Program Director
Respiratory Therapy
Washburn University
1700 College
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(785) 231-1010, ext. 1404

IMPACT OF NONINVASIVE VENTILATION ON ICU UTILIZATION

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Kaiser Permanente Medical Center, 975 Sereno Drive Vallejo, CA 94589-2485

Objectives: Acute respiratory failure is the most common indication for endotracheal intubation and mechanical ventilation which often results in unwanted complications, increased morbidity and mortality rate, and prolonged ICU length of stay We reviewed the current literature on noninvasive ventilation (NIV) as a first-line intervention in patients with acute respiratory failure (ARF) in correcting gas exchange abnormalities and in avoiding endotracheal intubation (ETI) The approximate success rate from these studies is 70%, with few complications. We describe our experience with NIV and the associated cost savings **Methods:** A protocol was developed and the respiratory staff instructed on the use of NIV Patients admitted to our ICU with ARF were evaluated as potential candidates for NIV and categorized by severity of respiratory failure. Patients who were hemodynamically unstable, exhibited multi-organ dysfunction with sepsis, altered mental status, or hypoxic ARF in whom the clinical condition could not be reversed in 48 hours were not considered candidates Arterial blood gases, clinical parameters for work of breathing, respiratory rate (RR), and heart rate (HR) were recorded prior to, during and after discontinuation of NIV The overall success and mortality rate was measured **Results:** Over 12 months, we tracked 155 episodes of NIV 113 episodes of intubation were potentially avoided, for an overall success rate of 73% There were 32 patients that failed NIV with and overall mortality rate of 47%, compared to no mortality in the successful group ("Do not intubate" patients were excluded) The average duration on NIV for the successful group was 1 6 days with an average length of ICU stay of 3 days The average duration for mechanically ventilated patients with ETI in 1993 for similar case mix was 6 6 days with 7 8 days of ICU stay The difference between NIV and invasive ventilation duration was 5 days per patient, resulting in a potential reduction 565 ventilator days for the 12 month period Based on our ICU cost of $1200 per day, $678,000 may have been saved for the year There were no deaths or complications from not intubating patients and instituting NIV All deaths following intubation were due to the patient's underlying disease and not to any delay in initiating mechanical ventilation The average RR in patients successfully supported before and after NIV was 28 and 19 respectively The average RR before and after in the failed group was 27 and 25 respectively, suggesting that persistent tachypnea after initiation of NIV may be a predictor for failure HR in the successful group was 110 before NIV and dropped to 98 after NIV The failed group showed an increase in HR from 108 to 115 suggesting persistent tachycardia may also be a predictor for failure In 1995 we tracked 196 episodes of NIV with an 85% success rate In 1996 this success continued **Conclusion:** We found NIV successful in most patients with respiratory failure of various etiologies, resulting in a considerable decrease in the number of ventilator days and significant cost savings We continue to use NIV as a standard of care in ARF

OF-97-015

A PEDIATRIC ASTHMA UNIT STAFFED BY RESPIRATORY THERAPIST DECREASES LENGTH OF STAY, COST AND CHARGES.

Timothy R. Myers RRT, Robert L Chatburn RRT, Carolyn Keresmar MD. Rainbow Babies & Children's Hospital and Case Western Reserve University Cleveland, OH

The purpose of this study was to determine the effects of an Asthma Care Unit (ACU) staffed by respiratory therapists on length of stay (LOS), hospital cost, charges to payers, carepath variances and post-discharge outcomes for children admitted to our hospital for asthma **METHOD** During the period from 9/1/96 to 1/31/97 patients were admitted to a newly-developed ACU staffed by respiratory therapists An historical control group was comprised of data from 10/1/95 through 8/31/96 from multiple patient divisions staffed by registered nurses. All patients had their asthma treatment managed by the same Asthma Care Path protocol Patients admitted to the pediatric intensive care unit were excluded from both study groups Care path variances (deviations from care path protocol) were tracked on a patient-by-patient basis. ACP protocol administers telephone follow-up surveys to track post-discharge comorbidity outcomes Mean values for demographics, inpatient outcomes and post-discharge outcomes were compared with t tests. Percentages by race were compared using a Fisher exact test Distributions by severity class were compared with the Chi Square test **RESULTS:** Demographic and outcome variables are shown in the table below as mean values Comparing the ACU and historical control groups, there were no differences in demographic variables or in the distributions by severity class

	Asthma Unit		**Historical Control**		**p-values**
Demographics					
Number	262		267		
Age (years)	6 3	(4 5)	6 8	(4 8)	0 1912
Non-Caucasian	75 7%		76 5%		0 8386
Severity Class					0 7919
Severe	126		132		
Moderate	30		32		
Mild	82		74		
Unknown	24		29		
Inpatient Outcomes					
Length of stay (days)	1 78	(0 75)	2 04	(0 85)	0 0003
Variances	2 70	(2 45)	9 40	(5 34)	<0 0001
Hospital cost/case	$1,375	($600)	$1,522	($750)	0 0234
Patient charge/case	$2,447	($1,079)	$2,732	($1,319)	0 0246
Quality of Life Outcomes					
Symptomatic Days	4 86	(7 7)	5 61	(7.2)	0 3463
School Days Missed	5.31	(3 60)	3 80	(4 46)	0 0256
Work Days Missed	3 98	(3 10)	3 31	(3 62)	0 3578

CONCLUSION An ACU staffed by therapists significantly reduced LOS and care path variances, while resulting in a more cost-effective use of resources. There was no significant increase in symptomatic days. Average cost (i e , hospital fixed plus variable) savings /case was $150 Estimated hospital cost savings /year (based on census of 900 patients) is $135,000 (an additional $150,000 was saved converting RN FTE's to therapists and patient care assistants

OF-97-021

THE USE OF REAL TIME DATA TO JUSTIFY PRODUCTIVITY OF SPECIFIC PROCEDURES.

Susan Rinaldo-Gallo, RRT, MEd and
Marcia Slaughter, RRT, Duke University Medical Center, Durham, North Carolina

Background: A consultant group was hired by Duke University Medical Center in 1994, to conduct an Operations Improvement (OI) study One purpose of the OI study was to determine departmental productivity by reviewing time standards for all clinical procedures. Indirect patient care procedures such as travel time, documentation, patient care rounds, and report were also included during this process All ancillary departments were evaluated during the study period. The OI study was finalized and the resultant measurement tool, utilizing these time standards, was implemented July 1, 1995 Respiratory Care managers were concerned with the results of the study and immediately began working with the Medical Center's Management Engineering (ME) Department to re-evaluate some of the OI findings. A Respiratory Care Information System (RCIS), ClimVision (CV) was implemented later that same month. The system is PC based, and allows for wireless communication between the department based PC network and bedside data entry by RCPs into handheld computers Patient care data is entered on a "real time" basis; as the therapy is being delivered Actual duration of each procedure is automatically calculated Method. It was determined that time standards for the following high volume procedures would be re-evaluated Intermittent Aerosol Therapy (IAT) and Metered Dose Inhaler (MDI). The actual duration for every IAT and MDI procedure performed for a four month period was sent from CV to ME. Following analysis of this data, a ME representative conducted observations (time studies) of these procedures being performed. The RCIS data and the observed time standards were used to calculate a Reasonable Expectancy Standard for IAT and MDI procedures Results The time standard for an IAT was increased by 2.35 minutes The time standard for a MDI was increased by 1.2 minutes This resulted in an increase in approved Full Time Equivalent (FTE) positions as shown on the chart below

	Previous Time Std (min)	New Time Std (min)	Per Cent Increase	Procedures Performed	Increased Time (hrs)	Increased FTEs
IAT	4 60	6 95	51 1	7,804	305 65	1 53
MDI	2 37	3.57	50.7	11,666	233.32	1 17
Total	6 97	10 52		19 470	537 97	2.7

Experience This was our first experience in challenging the results of an outside consultant group Without a departmental information system, this would have been much more difficult to do. Conclusion The re-evaluation of time standards of two high volume procedures resulted in approval of an additional 2 7 full time equivalent RCP positions.

OF-97-044

THE EFFECTS OF CHANGING ROLES ON JOB SATISFACTION AMONG RESPIRATORY CARE PRACTITIONERS.

Teresa J. Keppler, MSA, RRT, Ronald E. Dechert, MS. RRT. University of Michigan Health Systems. Ann Arbor, Michigan.

Background: Sweeping changes in the health care delivery system in the United States has lead to the need to find less costly ways of providing care to patients in acute care settings. Efficient utilization of health care resources is imperative if institutions plan to survive. One of the highest costs to any institution is human resources. Finding ways to shift work to less costly practitioners has become one way to control human resource costs. Respiratory Care Practitioners (RCPs) have been targeted as one possible group to assume new job duties in work redesign aiming to improve staff utilization. Adding new tasks and changing roles can affect job satisfaction. Assessing how these changes are perceived by the worker can help guide managers as they implement cross-training programs. Method: 1027 surveys were mailed to credentialed RCPs during the first two weeks of December 1996. The selection of the population was from the 51 Respiratory Care departments used for benchmarking through MECON - a data base service for peer comparison. The areas that were addressed for analysis include: overall job satisfaction, attitude towards cross-training, and attitude towards their profession. Questions were scaled using a Likert 5 point scale with 1= strongly agree, and 5=strongly disagree. Data was analyzed using the descriptive statistics of count and percentage and the relational statistic used was the Chi Square. Results: The study produced 364 responses with 354 useable surveys from respondents out of 16 different states for a 35% overall response rate. The split by gender was 53.1% female and 46.9% male. Most (61%) were members of the AARC, and 82.8% were Registered Respiratory Therapists. Most respondents (92.1%) worked in University-Teaching hospitals with 60.7% of these institutions having more than 500 beds. The survey respondents were experienced both in the field and workforce, with 47.7% having over 10 years' experience as an RCP and 61.3% with over 10 years' experience in the workforce. Most (72.6%) of the respondents cited staff therapist as their job title. When the data was analyzed as a whole, 89.9% of the population responded positively when asked if they liked the work they do. The percentage of positive responses for the extrinsic rewards of pay, benefits, liking supervisory staff, and liking co-workers were 49.1, 75.2, 64.7, and 87 respectively The intrinsic reward of opportunity for promotion drew a positive response from only 24% of the population. Feeling valued by supervisors evoked a positive response from 54.8% of respondents. The population as a whole had a positive attitude towards cross-training for new tasks. Only 35.9% of respondents gave a positive response when asked if they felt the profession of Respiratory Care was growing stronger. New tasks were viewed by 55.3% of the population as making them feel more professional. The majority of respondents felt they were an important part of the patient's health care team. For analysis of the study hypotheses, the respondents were grouped by the 31.1% who were cross-training and the 68.9% who were not involved in cross-training. This study found no significant difference between cross-training and non cross-training RCPs and their overall job satisfaction. Cross-training RCPs gave a more positive response when asked about extrinsic rewards than non cross-training RCPs, the difference approaching statistical significance. This study finds there is a significant difference between the two groups and their attitudes towards cross-training. The group that was already engaged in cross-training was the more positive one. This study finds there is a statistically significant difference between the two groups attitudes toward their profession. The cross-training group again responded more positively toward their profession. Conclusions: Respiratory Care managers should evaluate pursuing involvement in non-traditional therapies to achieve efficiencies in human resource management and reduce costs. Recommendation: Since the AARC is the national professional organization for RCPs, it should conduct a needs assessment of its membership to identify issues affecting attitude toward their profession. This study revealed that only 24% of the population felt that their jobs afforded them opportunity for improvement. It is important that Respiratory Care managers develop initiatives to maintain the job satisfaction of their workforce.

OF-97-058

AN INVESTIGATION INTO THE USE OF A CHARACTER TRAIT ASSESSMENT FOR RESPIRATORY CARE PRACTITIONERS IN UPPER EAST TENNESSEE

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BACKGROUND: A Respiratory Care Practitioner (RCP) is a trained healthcare professional with an academic and clinical education, consisting of essentials of respiratory therapy, cardio-pulmonary physiology, and diagnostic techniques. The literature suggests that a personality profile using character trait assessment (CTA) could be utilized as a component of the pre-employment interview, or to screen persons prior to admission to an RCP education program. PURPOSE: The purpose of this study was to determine the receptivity of RCP's to a character trait assessment utilized for hiring or promotion. A purposive, non-random study design was used METHOD: The researcher assembled a pilot group of RCP's; this group completed a questionnaire on the use of a character trait assessment (CTA) and they gave their feedback on the questionnaire's clarity and construction. A second, demographically similar group of RCP's (n = 42) participated in a 3-phase exercise where they first participated in the Personal Strengths Survey (PSS)(Smalley & Trent, 1990), a form of CTA The RCP's were encouraged to discuss their results based upon the authors' interpretation. In the second phase, they completed an inventory of 'Desirable Character Traits for Respiratory Care Practitioners' from the PSS. The group then responded to the same questionnaire on CTA from the pilot study with responses and data collated The questionnaires had identical administration techniques and only written instructions had been given to the pilot and phasic groups to prevent bias. RESULTS. There was an 84% return rate of the phasic study, with 31 female RCP's and 11 male RCP's responding (n = 42), five of whom identified themselves as supervisors. The responses on the questionnaire answered the research questions, and statistics were presented in a descriptive format Sixty-four percent of RCP's agreed to take a CTA when they knew the results would be used for hiring or promotion purposes One-hundred percent of RCP's favored one-on-one, face-to-face traditional interviews over CTA Forty-five percent of respondents agreed to a traditional interview and a CTA where the manager knew the results of the CTA and the interviewee did not, and 37% disagreed with this type of interview An interview technique using CTA with a face-to-face meeting, where both the interviewer and interviewee knew the results of the CTA, was favored by 67% of RCP's, with 28% not sure, and 5% disagreeing. All forty-two RCP's disagreed with a telephone (no face-to-face) interview regardless of the CTA component. CONCLUSION: RCP's were not more receptive to CTA after first-hand experience with it, and they believed that traditional interviews were more fair and valid in showcasing their capabilities than interviews using a CTA. The findings of the study were that RCP's in Upper East Tennessee were receptive to the concept of CTA if the results were known to both the applicant and manager, but they strongly embrace traditional interview techniques

OF-97-076

TWO-TIERED RESPONSE FOR EMERGENCY AIRWAY MANAGEMENT,

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Because of the potential for airway emergencies to result in serious morbidity and mortality, personnel trained in emergency airway management must be available at all times Faced with reductions in available anesthesia personnel at our medical center we evaluated possible models to ensure safe and timely care of airway emergencies without requiring around the clock presence of a physician trained in airway management We hypothesized that a hybrid two-level model of emergency airway care would result in safe management of airways with acceptable outcomes. Our model consisted of defining airway care as either urgent or emergent based on whether the patient was expected to require endotracheal intubation within 30 minutes Prior experience indicated that the majority of intubations actually occurred in patients who exhibited signs of progressive deterioration over a period of longer than 30 minutes and that anesthesia personnel could be paged to the medical center to participate in airway care Further, we had observed that the more complex airway problems (requiring MD involvement) were in patients who were deteriorating but had not yet arrested By contrast, after cardiac arrest, there is less of a need for considering the complexities of sedation, muscle relaxation, or hemodynamic instability We established a certification program in airway management for respiratory therapists Training included practice with mannikins, one-on -one teaching, lecture, written materials, and OR sessions with a minimum of 10 days in the OR, and included use of the Macintosh and Miller blades and Eschmann stylets Our results over the first year included 107 total out-of-OR intubations, 52 for arrest and 55 for other airway problems Of the non-code cases, 49 of 55 had an anesthesiologist present An anesthesiologist supervised 27 of 52 cardiac arrest intubations Of the 76 supervised intubations (supervised either because of daytime hours or because they were urgent rather than emergent), all were successfully intubated Anesthesiologists were not initially present for 31 intubations and of these, 2 were never intubated and both patients died Two patients were intubated by a surgeon who was present after an initial attempt by a RT was not successful, and one patient was supported with a bag and mask after initial unsuccessful attempts by RT and a thoracic surgeon at which time anesthesia arrived and intubated the patient This resulted in 26 successful unsupervised intubations by RT The unsuccessful intubations were in patients with difficult airways, one had massive facial swelling and the other was in a halo following trans-oral cervical spine surgery Neither patient had been expected to survive, and the anesthesiologist was also unable to intubate either patient Our model resulted in 105 of 107 patients intubated successfully. The 2% failure rate is well within reported rates for out-of-OR intubations. Thus, the two level response model is safe, yields acceptable outcomes, and allows a physician to be present for the non-arrest patients who often are unstable and have complicating factors Our model was also cost effective in that it has resulted in an estimated savings of $150,000 to the Medical Center since anesthesia personnel are not required to be in the Medical Center 24 hours a day

OF-97-093

A PENNY SAVED? ...
PEAK FLOW VS SPIROMETRY FOR PRE-OP ASSESSMENT

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Background: Peak flow instruments are valuable tools to monitor known asthmatics. In 1994, Dr. Badgett published an article in Chest, proposing that peak flow meters could be utilized along with patient history and exam to diagnose any degree of COPD This article was acted upon by general practice internists who began performing peak flow testing in pre-op patient assessments to rule out pulmonary disease, using a cut-off of ≤ 250 L/min Only if patients fell below the cut-off, were they sent to the pulmonary lab for spirometry testing. The clinic utilized medical assistants to test the patients peak flow rate using a disposable Assess Peak Flow meter, changing mouthpieces between patients. The Pulmonary department had concerns about the accuracy of peak flow monitors, and the utility of using a cut-off of ≤ 250 L/min, rather than a percent of predicted. There was concern that patients would be sent to surgery without proper pulmonary assessment and needed treatment with resulting increased morbidity. In an effort to evaluate the situation, we proposed to duplicate the clinic peak flow testing methods on all patients coming to the PFT lab along with the patient's routine scheduled PFT's The results of the two tests could be compared and evaluated **Methods**: Each patient arriving in the outpatient PFT lab, had peak flow testing performed, after instruction and demonstration, with a minimum of three trials, prior to routine PFT's. Assess Peak Flow monitors were used, with the mouthpiece changed between each patient. The PFT's were interpreted, then the peak flow efforts evaluated in comparison to the PFT results. 209 patients were tested, 109 Females and 100 Males. Mean age of 52.2, range 17 to 81. **Results** 53 patients had peak flow readings of ≤ 250 L/min, 28 had an interpreted PFT of severe obstructive pulmonary disease, 14 had moderate obstruction, 3 had mild obstruction, 2 had severe restriction and 6 had moderate restriction. 116 patients had peak flow results between 250 and 600 L/min Of those patients, 12 had PFT interpretations of severe obstructive pulmonary disease, 19 had moderate obstruction, 36 had mild obstruction, 2 had severe restriction, 6 had moderate restriction, and 8 had mild restriction, one had an upper airway obstruction and 27 had normal PFT's The remainder of the study patients had peak flow readings between 600 and 900 L/min. In this category, 3 had moderate obstruction, 18 had mild restriction, 4 had mild restriction, and 13 were normal. Of note there were 8 cases of severely impaired DLCO readings in the patients with peak flows ≥ 250 L/min **Conclusion**. Peak Flow monitors do not have the specificity to pick up all patients at risk of pulmonary complications for pre-op assessment Although all the patients that had peak flow readings ≤ 250 L/min had pulmonary disease, 117 patients with demonstrated pulmonary disease by routine PFT's had peak flow readings ≥ 250 L/min. Although money may be saved by performing peak flow rather than spirometry for pre-op assessment, the patient may lose in the long run if complications occur.

OF-97-123

A NOVEL METHOD FOR TRACKING AND ANALYZING VENTILATOR PATIENT HOMOGENEITY BY A VENTILATOR MANAGEMENT TEAM.

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INTRODUCTION: Analyzing respiratory care ventilator workload and setting up ventilator educational strategies requires data. Traditionally, the number of ventilator patients, ventilator days and the average ventilator length of stay (ALOSv) have been examined as a hospital wide number These would be representative if ventilator patients were homogeneous hospital wide Our Ventilator Management (VentMan) Team analyzes daily data on all ventilator patients with bedside computers and educates about ventilator management. HYPOTHESIS We wanted to analyze the homogeneity of intensive care unit ventilator patients with a ventilator patient tracking system (VentMan) METHODS The number of adult ventilator patients and ALOSv for adult ICU's were examined over a six month period (Jul96 - Dec96) from the VentMan database Data was sorted by ICU: Medical Respiratory (MRICU), Surgical (SICU), Neurosensory (NICU), and Cardiac Care (CCU). Four ventilator length of stay groups (LOSv) were identified < 4 days, 4 to 13 days, 14 to 24 days, and ≥ 25 days The data was also sorted by percent of patients (within each ICU) in each of the four LOSv groups RESULTS

Intensive Care Unit Data from Jul96 - Dec96 (% indicates percentage within each ICU)

	MRICU	SICU	NICU	CCU	Total
Ventilator Patients	124	138	177	240	679
ALOSv, days	13.26	7.34	8 70	3.97	7.58
% with LOSv < 4	28%	59%	53%	72%	56%
% with LOSv 4 to 13	49%	29%	25%	23%	30%
% with LOSv 14 to 24	11%	4%	12%	3%	7%
% with LOSv ≥ 25	12%	8%	10%	2%	7%

CONCLUSIONS: A wide range of ALOSv between ICU's (3 97 to 13 26 days) is demonstrated which represents varied ventilator patient populations separated by ICU The wide ALOSv range between ICU's is due to varied numbers of long LOSv (i e ≥ 14 days) versus short LOSv (i e < 14 days) Analysis of the data helps our institution focus education about 'quick extubation' patients for certain ICU's and weaning the 'difficult to wean' patients for other ICU's A single hospital wide ALOSv value or trend is not a good representation of ventilator patients since there is not homogeneity between ICU's Trends on specific populations within ICU's are necessary to accurately analyze ventilator patients

OF-97-169

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The Economic Impact of a Respiratory Care Consult Program

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INTRODUCTION: A respiratory consult system was implemented in response to inappropriate ordering of respiratory care in non-ICU settings. Inappropriate therapies consistently were maintained at a 30% rate for the past four years. We have previously reported the success of this program. The Effect of A Consult Service on Inappropriate Therapies. The Respiratory Consult Service evaluates patients and recommends therapy or discontinuation of therapy based on guidelines. These guidelines were formulated by a multi- disciplinary committee and approved by the Medical Board of the hospital. A respiratory consult is triggered when a new order is generated by a physician or if the physician requests a respiratory care consult. **METHODS:** A study was conducted evaluating 197 consultations after a physician ordered respiratory therapy. In fifty-eight (58) of the 197 orders, the consult therapist recommended additional therapy. In seventy-eight (78) of the 197 orders, the consult therapist recommended to discontinue ordered therapy and in sixty-one (61) of the remaining orders, the consult therapist recommended to modify the physician's order. Therapy volume saved was calculated based upon the average patient receiving three days of therapy. Chest Physical Therapy volume was calculated based upon a patient receiving 4 treatments per day (QID) for a total of 12 tx.'s per patient (20 min. of labor). Hand Held Nebulizer (HHN) averaged 6 tx.'s per day (Q4) for a total of 18 treatments per patient (15 min. labor). Metered Dose Inhaler (MDI) is equivalent to 10 min. of labor and was recommended Q4 (18 treatments per stay), Q6 (12 treatments) or self-administered which equaled 30 min. of training and scoring one time. **RESULTS:** In the 58 orders adding therapy, the consult service added 94.5 hrs. of labor to deliver 402 MDI tx.'s, instruct 28 patients to self-administer MDI's and 54 HHN treatments. 78 orders reviewed by the respiratory consult service recommended to discontinue therapy. This resulted in the elimination of 1,122 treatments (564 CPT tx.'s and 558 HHN tx.'s) which corresponds to 327.5 hours of labor. The remaining 61 of the 197 orders recommended to convert HHN therapy (1,098 tx.'s requiring 274.5 hrs. of labor) to MDI therapy (1,098 tx.'s requiring 183 hrs. of labor). This modification of physician orders saved 91.5 hrs. of labor. The consult service used one hour of labor for each of the 197 consultations resulting in a total of 197 hrs.Net savings are calculated below.

Labor Analysis Savings from Consult - 419 hrs. (327.5 hrs. from elimination of therapy,91.5 hrs. HHN to MDI conversion Expense from Consult - 291.5 hrs. (94.5 hr from added therapy, 197 hrs. performing consults)

Net Labor Savings - 127.5 hrs. ($2,550 in salary) CONCLUSION. The Respiratory Care Consult service saved 127.5 hrs. of labor. Without the consult service 510.5 hrs. of labor would have been added to the volume of the department. The service has not added additional expense to the department. In an era of critical pathways and the need to eliminate unnecessary care, the consult system ensures the delivery of appropriate care while improving distribution of human resources.

OF-97-001

A Respiratory Care Protocol Program in a Teaching Institution: A Nursing Perspective.

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Introduction: In our institution, nurses have traditionally been the primary non-physician assessors of the patient's overall status. With the implementation of our patient driven protocols (PDPs), Respiratory Care now shared this assessment role with the additional latitude to start, stop and modify therapy. We sought to determine how this role change affected nurses' perceptions of this program and the Respiratory Care Practitioners at this large metropolitan teaching institution. **Method:** A 13 question survey was distributed to the nurses. The survey was designed to gain insight on their perceptions on how our PDP program had impacted timeliness, quality and appropriateness of the respiratory care rendered, and the professionalism of the participating RCPs. Additional questions addressed the respondents demographics within the institution, their knowledge of our PDP program goals, the number of their patients that had been on the PDP program, and if the program should be expanded to include additional procedures. 97 questionnaires were sent to nurses on the medical and surgical firms. **Results:** 58 of the 97 surveys were returned (59.8%). 30 Medical and 28 Surgical Nurses responded, representing an even distribution of respondents 51.7% and 48.3% respectively. 45 of the 58 (77.6%) responding nurses felt they understood the goals of the program. There was no clear delineation of the response differences when analyzed by division, area (i.e. acute care, ICU, rehabilitation), shift or length of employment at the medical center. The tables below delineate the responses

Table 1 n = 58	Significant Decrease	Decrease	No Change	Increase	Significant Increase	No Response
Timeliness	2 (3%)	4 (7%)	9 (16%)	31 (53%)	11 (19%)	1 (2%)
Quality	0 (0%)	2 (3%)	14 (24%)	29 (50%)	13 (22%)	0 (0%)
Appropriateness	0 (0%)	2 (3%)	6 (10%)	35 (60%)	15 (26%)	0 (0%)
Professionalism	0 (0%)	1 (2%)	21 (36%)	26 (45%)	8 (14%)	2 (3%)

Table 2 n = 58	Yes	No	No Response
Should a PDP for hyperinflation be developed?	46 (79%)	12 (21%)	0 (0%)
Should a PDP for pulmonary hygiene be developed?	56 (97%)	2 (3%)	0 (0%)
Should a PDP for trach management be developed?	48 (83%)	10 (71%)	0 (0%)

Conclusion: The results indicate a favorable perception of the program among the responding nurses. Greater than 60% of the respondents identified an improvement in the respiratory care resulting from the program (Table 1). Also, the respondents supported the specific concepts for further expansion of the program (Table 2). This survey indicates that Respiratory Care Services can be expanded through PDP resulting in a favorable exceptance and support by nurses.

OF-97-016

PHYSICIANS' PERCEPTIONS OF A PROTOCOL PROGRAM

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Introduction: Patient driven protocols (PDPs) have gained wide acceptance within the Respiratory Care profession, however only anecdotal references can be found concerning the effect that these programs have on physicians' attitudes. We sought to gain insight into physicians' perceptions of a bronchodilator and oxygen PDP program at a large metropolitan teaching hospital. **Method:** A survey was developed consisting of 12 questions designed to determine physician perceptions specifically related to the effect that the POP program had on the timeliness, quality and appropriateness of the resulting respiratory care, and the professionalism of the RCPs participating in the process. Additional questions aimed to determine if the physicians felt that they understood the goals of the program, whether the PDPs helped them to manage patients with respiratory disorders and if the program should be expanded. 194 anonymous questionnaires were distributed to Attending and Resident physicians. **Results:** 54 of the 194 surveys were returned (27.8%). 28 Attending and 26 Resident physicians responded, representing a fairly even distribution of respondents at 51.9% and 48.1% respectively. The tables below identify the responses obtained.

Table 1 n=54	Significant Decrease	Decrease	No Change	Increase	Significant Increase	No Response
Timeliness	0 (0.0%)	4 (7.4%)	17 (31.5%)	21 (38.9%)	5 (9.3%)	7 (13.0%)
Quality	0 (0.0%)	3 (5.6%)	16 (29.6%)	24 (44.4%)	3 (5.6%)	8 (14.8%)
Appropriateness	1 (1.9%)	2 (3.7%)	13 (24.1%)	25 (45.3%)	5 (9.3%)	7 (13.0%)
Professionalism	1 (1.9%)	1 (1.9%)	22 (40.7%)	17 (31.5%)	5 (9.3%)	7 (13.0%)

Table 2 n=54	Yes	No	No Response
Do you feel that you understand the goals of the program?	37 (68.5%)	17 (31.5%)	0 (0.0%)
Does PDP help you manage patients?	35 (64.8%)	12 (22.2%)	7 (13.0%)
Should a PDP for hyperinflation be developed?	29 (53.7%)	19 (35.2%)	6 (11.1%)
Should a PDP for pulmonary hygiene be developed?	43 (79.6%)	6 (11.1%)	5 (9.3%)
Should a PDP for trach management be developed?	43 (79.6%)	5 (9.3%)	6 (11.1%)

Conclusion Although the response to this survey was not sufficient to generalize the findings to our entire physician population, the results do indicate a favorable perception of the program among the respondents. Most of the physicians identified that there was an improvement in the respiratory care resulting from the program (Table 1). Also, the majority of physicians indicated that the program helped them to manage their patients and that expansion of the program would be favorable to them (Table 2).

OF-97-018

EFFECT OF A PROTOCOL ON THE DIRECT COSTS OF PROVIDING BRONCHODILATOR THERAPY

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Introduction. One of the potential benefits of patient driven protocols is their ability to reduce costs by eliminating unnecessary care. We sought to determine the effect that a bronchodilator (BD) protocol would have on treatment volume and the direct costs of providing BD therapy. Method. We compared the number of BD treatments (MDI & SVN) for the 6 month period preceding the initiation of the protocol (Jan - June, 1995) with the number of treatments for the 6 months following protocol initiation (July - Dec., 1995). The following formula was used to correct for the effect that variations in hospital census would have on the number of treatments identified for the period following implementation of the protocol.

$$\frac{\text{Pre protocol census} \times \text{BD treatments post protocol}}{\text{Post protocol census}} = \text{Corrected BD treatments post protocol}$$

The overall effect on costs was then determined in two steps. First, the number of treatments in each period were multiplied by the direct cost for BD treatment administration as identified by the Hospital Accounting Department. Next, the total number of initial and follow-up assessments, associated with the implementation of the protocols, were each multiplied by the average RCP hourly wage and then by the fraction of an hour associated with each respective type of assessment. The assessment costs in the protocol period were added to the treatment administration direct costs and the sum was then subtracted from the treatment direct cost in the period prior to the protocol. The hospital Accounting Department identified that the cost per treatment did not change over the study period. Indirect costs and direct cost associated with staff training were not included in the analysis.

Results. Treatments for the pre and post protocol periods were 38,539 and 23,229 respectively, a difference of 15,310 treatments. Following correction for census variation, the number of BD treatments in the protocol period was 24,251. The difference between the two periods was 14,288 treatments. 2,560 initial and 1,535 follow-up assessments were performed during the protocol period with an average direct cost of $7.30 and $3.48 respectively. Corrected for census variation, the direct cost reduction was calculated as $67,986 for the 6 month period.

6 months	Before Protocol	After Protocol
Hospital census	12,860	12,318
Patients receiving BD therapy	1,909	1,331 (1,390)
Treatments	38,539	23,229 (24,251)
Therapy administration costs	$248,191	$149,595 ($156,176)
Patient assessment costs	0	$24,029
Total costs	$248,191	$173,624 ($180,205)
Savings		($67,986)

Values in parenthesis are corrected for variation in hospital census

Conclusion. Implementation of a patient driven bronchodilator protocol can decrease the volume of treatments and result in cost savings. Seasonal variation and the potential for differences in group severity may account for some of the savings identified in this analysis. Start-up costs associated with staff education and competency are a required component of a protocol program, however, are considered as a single major investment with minor maintenance costs. Although this study identified calculated cost savings, actual savings may vary from the calculated amount as staffing patterns and supply orders are adjusted.

OF-97-019

UTILITY OF ALGORITHMS FOR PULMONARY FUNCTION TESTS IN HOSPITALIZED PATIENTS

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Background In our large teaching hospital, inpatient physician orders are entered into an electronic Order Entry system (OE) by ward secretaries Since the inception of this system in 1996, a large percentage of the orders requested via OE have been for 'complete pulmonary function studies'. We undertook prospective data collection to help us understand this phenomenon.

Method: During the collection period 2/29/97 through 3 13 97, for all consecutive in-patient requests for pulmonary function, we prospectively collected the following information on each request physician order (as written), the order chosen by the ward secretaries from the OE list, diagnosis(es), pending surgery and site of pending surgery We examined the orders as written to determine if the order was specific (e g spirometry and diffusing capacity) or vague (e.g. PFTs) We compared the physician order with the order entry request When a vague written order was present, the technicians examined the patient's medical record to determine what test(s) were medically indicated

Results: Fifty requests for pulmonary function tests were received. Of these, 22 (44%) were completely vague (e.g PFTs) and another 9(18%) were at least partially vague (e g PFTs with DLCO) The remainder of the physician orders specified the test sufficiently Thirty (97%) partially or completely vague orders were entered into OE as "complete pulmonary function studies" a term defined by the system as spirometry, lung volumes by helium dilution and diffusing capacity (DLCO)

In 18 cases (82%) where the orders were completely vague, spirometry was the only pulmonary function test deemed to be medically necessary Of the remainder of the cases in which the written order was completely vague, the tests deemed medically necessary were spirometry, lung volumes and DLCO in two cases (11%), spirometry with DLCO in one case (6%) and spirometry, DLCO and arterial blood gas, one case (6%) In the nine cases where the orders were partially vague, spirometry and DLCO were deemed necessary in all cases (100%).

Conclusions: 1 Physician orders for inpatient pulmonary function testing are often completely or partially vague 2 Ward secretaries at our institution routinely translate vague written orders into electronic orders for complete pulmonary function tests 3 When pre-defined appropriateness criteria are used to determine what test is necessary, more expedient, less costly testing is the result in the majority of cases

Discussion: In teaching hospitals, there is a high turnover of resident physicians and vague orders are common The use of pre-determined algorithms by the Pulmonary Lab technologists to determine the test(s) to be performed may be an alternative to the current system

OF-97-029

A METHOD FOR EVALUATING RESPIRATORY THERAPISTS' CARE PLANS FOR A RESPIRATORY THERAPY CONSULT SERVICE.

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BACKGROUND: The Respiratory Therapy Consult Service (RTCS) was initiated in 1992 and has been mandated to direct the respiratory care provided to most adult non-ICU inpatients at the Cleveland Clinic Foundation since December, 1994 A respiratory therapy consult is generated when a physician writes an order for a consult or when specific orders are written for respiratory therapy treatments. In performing a consult, a therapist evaluator sees the patient, conducts an assessment using specific indications and then, following associated algorithms, writes a care plan. To help assure that the care plans being written by the Respiratory Therapist evaluators are appropriate, we initiated an audit strategy in March, 1996, as described below **METHOD:** Two care plans per week are audited by our education coordinator (L.K.), who sees the patient within 24 hours following the evaluation by the therapist, conducts an assessment, while blind to the other therapist's care plan, and writes a care plan based only on clinical information available at the time of the therapist's evaluation. The auditor's care plan is then compared with the therapist evaluator's plan for agreement or disagreement on each of the 8 assessment categories as well as each of the 6 care plan items Feedback is provided to the therapist evaluator on a simple form that summarizes % agreement between the auditor and the evaluator on ratings for each of 8 assessment items and % agreement on 6 treatment modalities. Audit results are presented for the 24 patients sampled each quarter. **RESULTS:** Table 1 presents the results of the first 9 months' experience rating % agreement on assessment ratings and respiratory care modalities and mean workload for the quarter, summarized by work units (WU's, where 1 WU equals 1 min.). As shown, the % agreement on assessment items and respiratory care modalities are consistently high across quarters, with greater agreement on respiratory care modalities than assessment items. Variation in workload WU's did not exert a consistent effect on % agreement, suggesting that agreement with a "gold standard" care plan was unaffected by the workload

Quarter	% Agreement on Triage Score Items	% Agreement on Treatment Modalities	Average Work Load (WUs)
1	84 7%	92.6%	298 7
2	87.3%	93.0%	277.0
3	86 7%	96 5%	280 2

Care plan scores appear to be improving over time The slightly lower assessment scores could be attributed to a change in patient status during the time elapsed between the therapist's evaluation and the auditor's evaluation, and also to a degree of subjectivity in some of the assessment categories.

CONCLUSIONS:

1. Implementing an audit process is an important step to assure quality and consistent inter-therapist performance in a RTCS.
2. Preliminary data from the first 9 months of audits suggest high percent agreement between auditor and therapists regarding use of respiratory care modalities and assessment ratings.
3. Though longer term data are needed, this preliminary study did not suggest that workload variation within the range observed exerted an effect on correct implementation of respiratory care protocols.'

OF-97-050

THE EFFECT OF PROTOCOLS ON RESPIRATORY CARE PRACTITIONERS SELF PERCEPTIONS; EXPERIENCE IN A LARGE TEACHING HOSPITAL

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Introduction: Our Department developed and implemented respiratory care protocols allowing the Respiratory Care Practitioners (RCPs) to assess, modify, or stop therapy We sought to determine how this expanded role was perceived by the RCP in our Department **Method** A twelve question survey was developed and distributed to our RCPs The survey was designed to determine how the RCPs felt the protocols effected the care given to patients and how RCPs perceive their role change Fifty-seven surveys were distributed to our RCPs **Results** Twenty-six of the fifty-seven surveys sent were completed and anonymously returned (46%) Twenty of the respondents (77%) have been RCPs for six years or more Six respondents (23%) have been RCPs for less than six years The tables below delineate the responses

Workload	Significant Decrease	Decrease	No Change	Increase	Significant Increase
RCP <6 yrs	0 (0%)	3 (12%)	0 (0%)	1 (4%)	2 (8%)
RCP ≥6 yrs	1 (4%)	4 (15%)	5 (19%)	8 (30%)	2 (8%)

Quality of Work	Significant Decrease	Decrease	No Change	Increase	Significant Increase
RCP <6 yrs	0 (0%)	0 (0%)	0 (0%)	2 (8%)	4 (15%)
RCP ≥6 yrs	0 (0%)	0 (0%0	3 (12%)	13 (50%)	4 (15%)

Appropriateness	Significant Decrease	Decrease	No Change	Increase	Significant Increase
RCP <6 yrs	0 (0%)	0 (0%)	0 (0%)	5 (19%)	1 (4%)
RCP ≥6 yrs	0 (0%)	0 (0%)	1 (4%)	12 (46%)	7 (27%)

Professional image	Significant Decrease	Decrease	No Change	Increase	Significant Increase
RCP <6 yrs	0 (0%)	0 (0%)	0 (0%)	4 (15%)	2 (8%)
RCP ≥6 yrs	0 (0%)	0 (0%)	2 (8%)	15 (57%)	3 (12%)

Professional image by others	Significant Decrease	Decrease	No Change	Increase	Significant Increase
RCP <6 yrs	0 (0%)	0 (0%)	1 (4%)	4 (15%)	1 (4%)
RCP ≥6 yrs	0 (0%)	0 (0%)	1 (4%)	15 (57%)	4 (15%)

Conclusion: Although some RCPs thought the workload was increased, the results of this survey show an overall favorable perception of the use of respiratory care protocols and an enhanced sense of professionalism

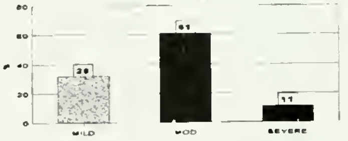
OF-97-041

IMPACT OF "RESPIRATORY THERAPIST-DRIVEN" ACUTE ASTHMA GUIDELINES IN A PEDIATRIC EMERGENCY DEPARTMENT-A PRELIMINARY REPORT.

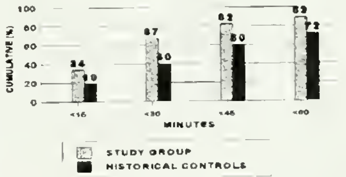
Scott Pettinichi, BA, RRT, Steve Smith, RRT, Roy Kulick, MD, MS, Uma Kotagal, MBBS, MSc

Background: As part of a multidisciplinary team, respiratory therapists (RT), who are decentralized to the Emergency Department (ED), assisted in developing acute asthma guidelines The guidelines included in asthma intake form to gather comprehensive history, a clinical pathway and an asthma flow chart. These guidelines empowered the RT to perform initial respiratory assessment and vital signs, to administer the 1st nebulized treatment (NEB), and to facilitate early steroids **Method:** The guidelines were evaluated prospectively on 400 patients (out of 1400 potentially eligible) from 9/96 - 1/97 The study group (SG) was compared to a historical control group (HC) of 563 patients treated in the ED from 3/95-6/95 **Results:** The asthma flow chart allowed us to estimate severity in the SG (Table 1) Time to the 1st NEB was decreased in the SG (Table 2, p=.001) A higher proportion of the SG received steroids (Table 3, p=.001) Admission rate was 37% in the SG compared to 31% in the HC (p=.046) However, the Admission rate for all 1400 patients seen during the study period was 25% **Experience:** Based on these preliminary results, greater RT autonomy in the management of acute asthma may facilitate improved care We will continue to assess the impact of this program **Conclusion:** "RT-driven" acute asthma guidelines resulted in significant process improvements, decrease time to 1st NEB and increase steroid use We suspect the increased Admission rate in the SG reflects the fact that 72% had moderate to severe exacerbations However, final assessment of the impact on Admission rate will require further analysis

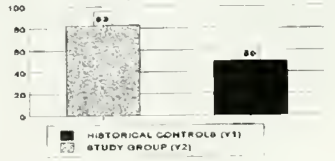
STUDY GROUP
Severity (TABLE 1)



TIME TO FIRST NEB
(TABLE 2)



ED STEROID USE
(TABLE 3)



OF-97-059

THE EFFECT OF A THERAPIST DRIVEN WEANING PROTOCOL ON THE DURATION OF MECHANICAL VENTILATION IN POST CARDIAC SURGICAL PATIENTS

Gregory Webby, RRT, Morris Brown, MD, Linda K Zimcosky, RRT, Detroit Medical Center-Sinai Hospital, Detroit, Michigan

INTRODUCTION Traditionally, cardiac surgical patients remained intubated and mechanically ventilated for up to 24 hours postoperatively However, there is increasing data to suggest that, with the use of a therapist driven weaning protocol, intubation and mechanical ventilation time can be significantly decreased This study was undertaken as a quality improvement effort as part of a critical pathway to reduce the duration of intubation, mechanical ventilation, ICU length of stay (LOS) and cost, following cardiac surgery by using a therapist driven weaning protocol METHODS AND MATERIALS All patients who underwent coronary artery bypass grafting (CABG) between October, 1994 and September, 1996, were reviewed This study was restricted to the uncomplicated post-cardiac surgical patient This was defined as patients 1) with no history of insulin dependent diabetes mellitus, 2) less than 70 years old, 3) undergoing initial CABG, 4) with no significant left ventricular failure, and 5) with no history of failed percutaneous transluminal coronary angioplasty The evaluation included patient demographics, duration of intubation and mechanical ventilation, complication rate and overall LOS in the Surgical Intensive Care Unit (SICU) All patients had the medical staff approved therapist driven protocol utilized for weaning patients from mechanical ventilation RESULTS A total of 119 patients met the inclusion criteria during the two year study period There were 71 males and 48 females Ages ranged from 35-69 years old (mean 58 years) Implementation of the therapist driven weaning protocol resulted in a median intubation time of eight hours (range 1 5-27 hours) post arrival into the SICU, or a 63% reduction in the duration of mechanical ventilation During the study period, there was no increase in complication rate, as defined by either a readmission to the SICU, or reintubation Patient LOS in the SICU fell an average of one day, facilitating an earlier transfer to the stepdown unit and progression to cardiac rehabilitation In addition, ICU costs were reduced during the study period CONCLUSIONS The implementation of a therapist driven weaning protocol is an effective means to decrease intubation and mechanical ventilation time, LOS and cost in the SICU, without increasing complications The weaning protocol is an integral part of a critical pathway for patients undergoing CABG surgery

OF-97-077

THE IMPACT OF AN ARTERIAL BLOOD GAS ALGORITHM ON ORDERING PRACTICES IN A MEDICAL ICU.

Douglas K Orens, MBA,RRT Pat Perez-Trepechio, BS,RRT James K Stoller, MD, Cleveland Clinic Foundation, Cleveland, OH

BACKGROUND: Previous studies have suggested that adherence to an arterial blood gas algorithm can lessen the frequency of inappropriately drawn arterial blood gases in a Surgical Intensive Care Unit As part of our ongoing assessment of the impact of respiratory care protocols, we conducted a controlled study to examine whether an algorithm for arterial blood gas sampling lessened the volume and associated costs of arterial blood gases **METHODS:** The arterial blood gas algorithm was developed by members of the Section of Respiratory Therapy in accordance with relevant AARC Clinical Practice Guideline's Overall, the algorithm suggested sampling an arterial blood gas under specific conditions,. e g hemodynamic instability, pre-and post-extubation, during active weaning from mechanical ventilation, increasing F102 requirements Using a management information system to tally the number of arterial blood gas samples and a cost accounting system (Transition Systems, Boston, MA) that allowed for variable and fixed costs associated with arterial sampling to be calculated, we compared the volume and cost of arterial blood gas sampling in two similar periods, both before (8/95 - 3/96) and then again after (8/96 - 3/97) implementing the algorithm Prior to implementing the algorithm, arterial blood gases could be obtained on request by physicians, nurses or respiratory therapists In implementing the algorithm, respiratory care practitioners in the ICU were specifically trained and the algorithm was made available to other health care providers **RESULTS:** During the 8 month control period (before algorithm implementation), 531 patients accounted for 2,334 ventilator-days in the 12-bed Medical ICU During this period, 11,435 arterial blood gas samples were drawn (mean 4 9 arterial blood gases per ventilator-day) For the 8 month period after implementing the arterial blood gas algorithm (8/96 - 3/97), 462 patients accounted for 2665 ventilator-days and the number of arterial blood gas samples decreased to 6,620 (mean 2 5 arterial blood gases per ventilator-day, for a 49% reduction) The observed decrease in the number of arterial blood gases was associated with a cost savings of $62,210 Furthermore, comparison between the study and control periods showed no significant difference in Medical ICU mortality rates (24%[study period] vs. 23 3%) or ICU re-admission rates (13 6% vs 11.3%) **CONCLUSIONS:** We conclude that the availability of an arterial blood gas sampling algorithm can be associated with significant decreases in the volume of arterial blood gas sampling and substantial cost savings without recognizable adverse events This reduction occurred despite a 14% increase in the number of ventilator-days during the compared time periods Implementation of an arterial blood gas sampling algorithm appears to be a cost-effective tool in a Medical ICU, extending previous observations from the Surgical ICU experience

OF-97-104

MEDICAL HOUSE STAFF IMPRESSIONS REGARDING THE IMPACT OF A RESPIRATORY THERAPY CONSULT SERVICE,

Irene Michnicki RRT, James K Stoller MD, The Cleveland Clinic Foundation, Cleveland, Ohio

Background: Although the Respiratory Therapy Consult Service (RTCS) has been shown to be effective in enhancing the allocation of respiratory care services, the criticism has been lodged that allocating algorithm-based decision-making to respiratory care practitioners detracts from physicians'-in-training knowledge of respiratory care To assess whether medical house staff regarded a well-established RTCS to be clinically and educationally helpful, we undertook a survey of house staff attitudes regarding the impact of this service on both patient care and house staff skill in ordering respiratory care **Methods:** A single page, 6 question instrument was distributed at a regularly s heduled meeting of the Cleveland Clinic Foundation medical house staff The questions posed were

1 Do you know what the Respiratory Therapy Consult Service (RTCS) is?, 2 Do you feel the RTCS is helpful or detrimental to the care of your patients?, 3 Do you feel it has enhanced or detracted from your knowledge of respiratory care ordering?, 4 Do you have a Respiratory Therapy Consult handbook?, 5 Have you read it?, 6 Have you found it helpful? **Results:** Of a total of 95 available members of the medical house staff, 62 attended the meeting (65%) and 41 submitted responses (66% of attendees) Of the 41 respondents, 95% were aware of the RTCS Similarly, 97% regarded the RTCS as being helpful to the care of their patients. Of 34 respondents, 56% felt that the RTCS enhanced the house staff's knowledge of respiratory care ordering, 32% felt that the Consult Service detracted from the house staff's knowledge, and 12% indicated that the RTCS had neither effect Twenty-seven percent (11/41) indicated that they had an RTCS handbook, 19% (7/36) had read the handbook, and 33% (5/15) found it helpful **Conclusions:** We conclude that the majority of responding house staff at the Cleveland Clinic Foundation were aware of the Respiratory Therapy Consult Service, suggesting successful institutional notification about the service Similarly, almost all house staff regarded the Consult Service as being helpful in caring for their patients (97%), but only 56% felt that the Respiratory Therapy Consult Service enhanced the house staff's knowledge of respiratory care ordering, suggesting some educational concern about this service Further study is required to examine whether these impressions about the impact of the Respiratory Therapy Consult Service are supported by direct measureof the house staff's knowledge of respiratory care ordering

OF-97-105

ADMINISTRATION OF IV CONSCIOUS SEDATION BY RESPIRATORY CARE PRACTITIONERS: THE EFFECT ON PHYSICIAN PRACTICE.

David Wheeler RRT, Ken Hargett RRT, Cathy Meents RRT, Rusty Reid RRT, The Methodist Hospital, Houston, Texas

Introduction: Conscious Sedation is utilized to decrease anxiety, provide analgesia, produce amnesia or any combination of these for the purposes of diagnostic, therapeutic, or surgical procedures Conscious sedation is administered in many areas of the hospital and has been highlighted by JCAHO to determine if adequate policies and procedures exist to insure patient safety. Our hospital assigned a multi disciplinary task force to develop and implement an institution wide Conscious Sedation policy The Respiratory Care Department provides the bronchoscopy services for the entire hospital and was included on the task force A formal hospital level policy approved by Anesthesia, Pharmacy and Therapeutics, and Medical Staff Executive Committee was developed The policy designated that only competency verified RN's and Registered Respiratory Therapists could administer conscious sedation utilizing a strict protocol. **Methods** A self-study program was developed and Registered Therapists within the department were competency verified to administer and monitor conscious sedation during bronchoscopy A post test was administered and a skills checkoff was included in the competency verification **Experience:** Prior to the development of the Conscious Sedation policy, administration of conscious sedation drugs was uncontrolled and unmonitored Over-sedation results in increased patient risk and necessitates reversal agents which result in additional cost to the hospital/patient in regards to drugs and monitoring time The cost of Mazicon to the department is $30 00/dose As part of the Respiratory Care Quality Improvement process, the administration of conscious sedation was monitored specifically looking at reversal of conscious sedation as an indicator of overdose A retrospective review of bronchoscopy records showed that in the nine months prior to the implementation of the policy, 20% (121/609) of patients undergoing bronchoscopy had to be reversed After the implementation of the policy and rigid adherence to the uniform protocol by the Respiratory Therapist a decline in reversal rates was noted Initially, the reversal rate fell to 8%(19 /232) over the first three months. As more Respiratory Therapist were trained, the reversal rate fell to 4% over the next nine months (39/935). This decrease in reversals resulted in a cost savings of $4400 during this period **Conclusions:** Within our institution, we have demonstrated that Registered Respiratory Therapists , following a carefully designed Conscious Sedation Protocol, can effectively administer IV conscious sedation Our reversal rate for excessive sedation during bronchoscopy has decreased from 20% to 4% We conclude that meticulous monitoring of conscious sedation administration by a Registered Respiratory Therapist has favorably altered physician practice as evidenced by the significant reduction in patients requiring analgesic reversal This change in physician practice has resulted in a cost savings to the Respiratory Care Department

OF-97-107

INTERMIT AEROSOL TREATMENT STANDARDIZATION AND ASSESSMENT PROGRAM

Susan Rinaldo-Gallo, MEd, RRT and Janice Thalman, BS, RRT. Duke University Medical Center, Durham, NC

Duke Respiratory Care Services (RCS) administers over 102,000 aerosol treatments (Txs), on Intermediate Care annually. Ordering strategies for these therapies were traditionally physician discretion. This led to a wide range of ordering frequencies and device selections. In an effort to provide more cost-effective therapy, Duke RCS established a consult service. This service was designed to have specially trained RCPs to interact with individual physicians to improve ordering practices. However, busy physician schedules, physician misunderstanding of bronchodilator pharmacology and RCS staff reductions have contributed to making this system inconsistent.

To provide a more effective service, Duke RCS in conjunction with Duke Hospital Pulmonary Division, Critical Care Committee, Credentialling Committee and with the endorsement of the Pharmacology and Therapeutics Committee and chairmen from the three major clinical departments, developed a standardized aerosol therapy delivery practice that would provide a control mechanism for more efficient resource utilization.

All bronchodilator orders would now be assessed by RCPs and classified as "Standard" or "Acute". All standardized therapy would be delivered QID or QID/QHS with Albuterol 2.5 mg by nebulizer or 2 puffs by MDI and/or Ipratropium .5 mg by nebulizer or 2 puffs MDI and/or inhaled steroids, per package insert dose. Orders assessed as acute would be consensus driven with the RCP and physician constructing a care plan. The Hospital Medical Records Committee subsequently authorized a specially trained advanced RCP to rewrite physician orders in the medical record The physician would now be notified by sticker that the original order was changed to "standard" aerosol therapy. The physician must co-sign in 24 hours and could override it at any time.

Aerosol treatment orders were reviewed for 3 months pre and post implementation of this new system. The number of Txs ordered but not given, decreased by 4.18% representing 344 Txs that no longer required RCP time More importantly, the number of orders requiring Txs after midnight decreased substantially (table below), resulting in a reduction of one full time RCP from night shift

Monthly Averages	No. Txs ordered	% of Orders after midnight
Pre Protocol, Aug - Oct	8478	50.9
Post Protocol, Nov - Jan	8564	7.9

We conclude that this new system has resulted in more appropriate and cost effective care

OF-97-118

A RANDOMIZED CONTROLLED TRIAL OF RESPIRATORY THERAPY CONSULT SERVICE-DIRECTED vs PHYSICIAN-DIRECTED RESPIRATORY CARE TO ADULT NON-ICU INPATIENTS

James K. Stoller, M.D., Ed Mascha, M S., David Haney, R.R.T and the Section of Respiratory Therapy, Department of Pulmonary and Critical Care Medicine, Cleveland Clinic Foundation, Cleveland, Ohio.

Introduction: Although available evidence suggests that respiratory care (RC) protocols can enhance allocation of RC services while conserving costs, a randomized trial is needed to address shortcomings of available studies We therefore conducted a randomized controlled trial comparing respiratory care directed by a Respiratory Therapy Consult Service (RTCS) vs. by managing physicians to adult non-ICU inpatients **Methods:** Eligible subjects were adult non-ICU inpatients whose physicians had prescribed specific respiratory care services. Consecutive eligible patients (pts) were approached for consent, after which a blocked randomization strategy was used to assign pts to Physician-directed RC, in which the prescribed physician respiratory care orders were maintained (n=74), or 2. RTCS-directed respiratory care, in which the physician's respiratory care orders were pre-empted by a RC plan generated by the RTCS (n=71) Specifically, these pts were evaluated by an RTCS therapist evaluator, whose RC plan was based on sign-symptom-based algorithms drafted to comply with AARC Clinical Practice Guidelines Appropriateness of respiratory care orders was assessed as agreement between the prescribed RC plan and an algorithm-based "standard care plan" generated by an expert therapist who was blind to the actual patient's orders **Results:** The compared groups were similar at baseline regarding demographic features, admission diagnostic category, smoking status, and Triage Score (mean 3 8 ± 0.9 (S D) [RTCS] vs. 3 7 ± 1 0) Similarly, no differences were observed between RTCS-directed and physician-directed RC regarding hospital mortality rate (5.7% vs. 5.6%), hospital length of stay (7 9 ± 9.0 vs 7.7 ± 7 3 days), total number of RC treatments delivered (30.3 ± 30 vs 31 6 ± 30 5), or days requiring respiratory care (4 2 ± 5 2 vs. 4 1 ± 3.6).Notably, using both a stringent (S) and a liberal (L) criterion for agreement, RTCS-directed respiratory care demonstrated better agreement with the "standard care plan" (82 ± 17% [S] and 86 ±16% [L]) than did physician-directed RC (64% ± 21% [S] and 72 ± 23% [L], $p<0\ 001$) Finally, the true costs of RC treatments was slightly lower with RTCS-directed RC (mean $235.70 vs $255.70/pt, $p=0\ 61$). **Conclusions:** We conclude 1. Compared to physician-directed respiratory care, the Respiratory Therapy Consult Service prescribed a similar number and duration of respiratory care services at a slight savings and without any increased adverse events. 2. Respiratory Therapy Consult Service-directed respiratory care showed greater agreement with Clinical Practice Guideline-based algorithms, suggesting decreased misallocation of respiratory care services 3 In showing that length of stay is equal between compared groups when similar baseline Triage Scores are assured by randomization, the current randomized trial addresses some of the important methodologic shortcomings of prior observational studies

OF-97-152

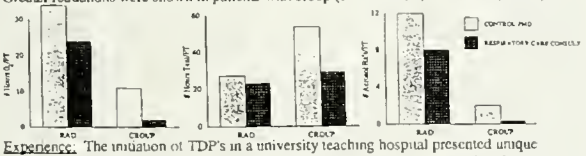
THERAPIST DRIVEN PROTOCOL (TDP) IN A CHILDREN'S HOSPITAL: ENHANCED PATIENT CARE, RESOURCE UTILIZATION, AND MEDICAL STAFF EDUCATION

Marc Leaderstorf, RRT, Dale Bloomberg, RRT, Patricia Mauro-Schukraft, RRT, Corinne L. Leach, MD, PhD. Departments of Respiratory Care and Pediatrics, Children's Hospital of Buffalo, State University of Buffalo, Buffalo, NY.

Background: TDP's have been developed in recent years to optimize resource utilization in the adult hospital setting. We hypothesized that a respiratory care practitioner's (RCP) expertise in evaluation and treatment of patients requiring respiratory care could be more effectively applied in a tertiary care pediatric teaching hospital

Methods: Two hundred thirty one pediatric patients who required respiratory intervention during a single hospital stay were managed by either a private physician (control group) or according to TDP's (TDP group). A team of RCP's and medical faculty in Pediatric Allergy and Immunology, Pulmonology, University Pediatrics, and private practice developed an evaluation program. This included a format for comprehensive respiratory assessment on admission based on history, physical exam, chest radiographs, and laboraties, from which a determination of severity of illness (triage score) was made. The triage score was used to determine frequency of treatments which were deemed appropriate according to algorithms for bronchodilator aerosol treatments and chest physicial therapy Algorithms were derived for bland aerosol (tent), and croup therapy as well. Through this evaluation program, the RCP formally recommended a course of treatment. The resident also evaluated the patient according to the TDP, and after discussion and agreement on a treatment plan with the RCP, wrote orders. Patients were reevaluated by the RCP at the time of each treatment, and plans adjusted as needed. Patient days, number of treatments, hours of therapy, severity of illness, and readmissions were recorded.

Results: For patients with reactive airway disease (RAD), the TDP group (n=38) showed a 29% decrease in oxygen hours per patient, a 15% decrease in tent hours, and a 35% decrease in number of aerosol treatments per patient as compared with the control group (n= 193) Length of stay was decreased 14% in the TDP group, with no increase in readmissions. Greater reductions were shown in patients with croup (control n=58; TDP n=16, Table).



Experience: The initiation of TDP's in a university teaching hospital presented unique challenges, in particular the development of mutually acceptable treatment plans by the housestaff, private physician and RCP. The overall professional interaction between RCP and physician expanded. Many private physicians requested the evaluation program for their patients, and it has since expanded to include all non-intubated pediatric patients who require respiratory care. Through this TDP program, a standard for respiratory evaluation was developed, from which both physician and RCP draw.

Conclusion: TDP's appear to optimize respiratory care resource utilization, while enhancing patient care. A strong, cooperative team approach between RCP and physician is needed to make this system work.

OF-97-179

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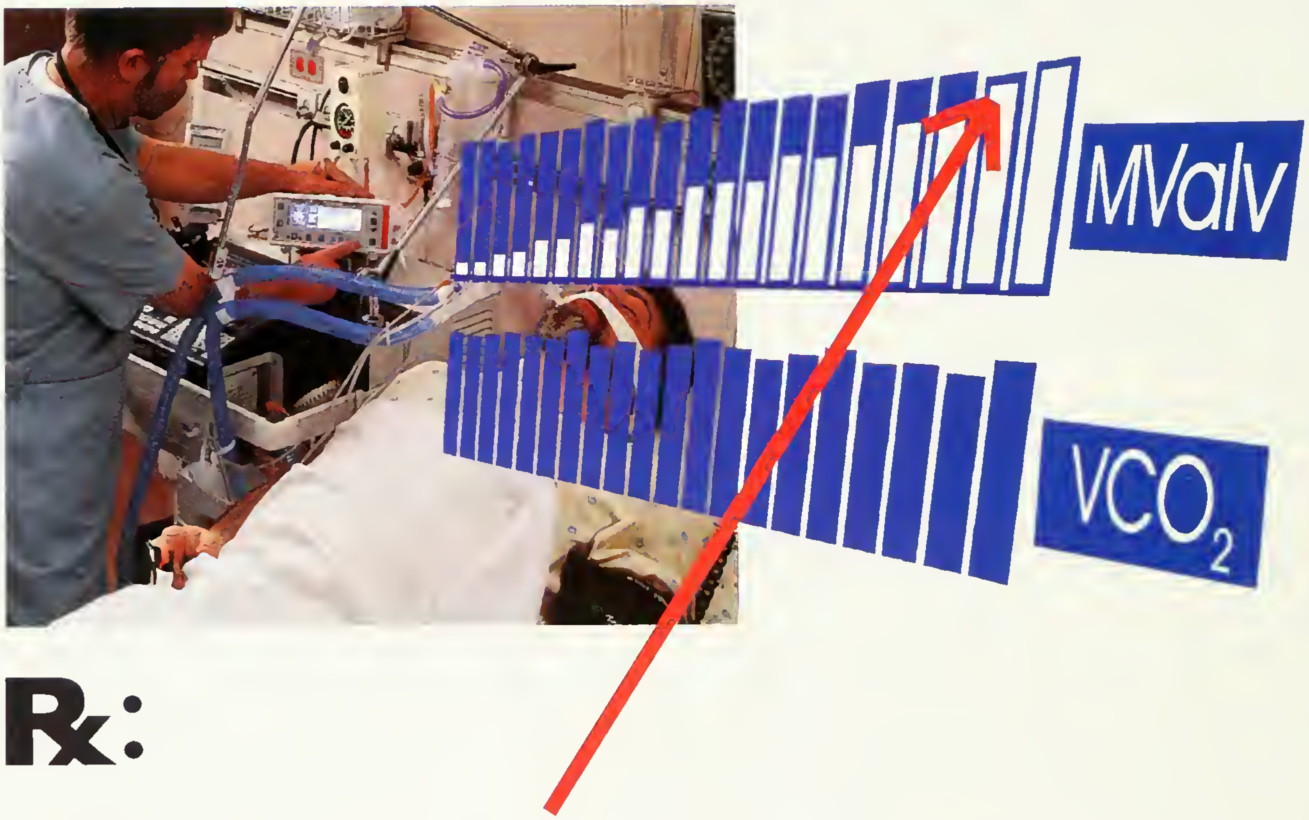

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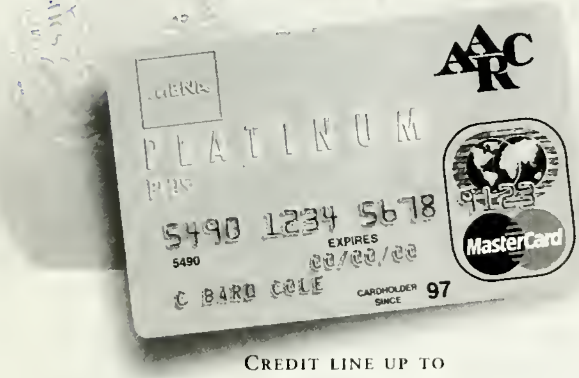

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New Address & Telephone Number

The National Board for Respiratory Care—1998 Examination Dates and Fees

Examination	Examination Date	Examination Fee
CRTT Examination	March 14, 1998 Application Deadline: January 1, 1998	$100 (new applicant)* 60 (reapplicant)*
	July 11, 1998 Application Deadline: May 1, 1998	100 (new applicant)* 60 (reapplicant)*
	November 14, 1998 Application Deadline: September 1, 1998	100 (new applicant)* 60 (reapplicant)*
RRT Examination	June 6, 1998 Application Deadline: February 1, 1998	120 Written only (new applicant) 80 Written only (reapplicant)
		130 CSE only (all applicants)
	December 5, 1998 Application Deadline: August 1, 1998	250 Both (new applicant) 210 Both (reapplicant)
CPFT Examination	June 6, 1998 Application Deadline: April 1, 1998	130 (new applicant) 100 (reapplicant)
RPFT Examination	December 5, 1998 Application Deadline. September 1, 1997	180 (new applicant) 150 (reapplicant)
Perinatal/Pediatric Respiratory Care Specialty Examination	March 14, 1998 Application Deadline: November 1, 1998	180 (new applicant) 150 (reapplicant)

*In 1999, this examination fee will increase by $20.

For information about other services or fees, write to the National Board for Respiratory Care, 8310 Nieman Road, Lenexa KS 66214, or call (913) 599-4200, FAX (913) 541-0156,or email nbrc-info@nbrc.org

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$2,000

Allen DeVilbiss Technology Paper Award

Best paper published from November '96 to November '97 that addresses new technology or a new application of current technology in respiratory care

Winner also receives airfare and 1 night's lodging for the 1997 International Respiratory Congress

$1,000

Best Original Paper

Papers under consideration for this award are those accepted for publication from October '96 to November '97

Winner also receives an ARCF Certificate

$1,000

Radiometer Awards for Best Feature Articles

Selected from Test Your Radiologic Skill, Blood Gas Corner, Kittredge's Corner, PFT Corner, Graphics Corner, and Cardiorespiratory Interactions accepted for publication from October '96 through November '97

Three winners share the cash prize and each receives an ARCF Certificate

1997 Literary Awards

arcf

The American Respiratory Care Foundation

At the 43rd International Respiratory Congress...

DON'T MISS "Critical Evaluation of Published Research"

Presented by
the Editorial Board of RESPIRATORY CARE
Tuesday, December 9, 1997 9:00–11:00 AM Rooms 20–22–24

James K Stoller MD—Cleveland, Ohio / Chairing

How Can I Manage the Information Explosion?

9:00–9:30 AM

Shelley C Mishoe PhD RRT
Medical College of Georgia
Augusta, Georgia

Describes the extent of "required" reading necessary to be up-to-date in your practice, and emphasizes selecting the journals to review, screening the contents, and selecting papers for further consideration. Details the differences between editorials, case reports, original research, and reviews. What's important in the research abstract? Should you read more of the paper? Where do electronic media fit?

How Can I Tell If What They Say Is True?

9:30–10:15 AM

Joseph L Rau Jr PhD RRT
Georgia State University
Atlanta, Georgia

Focuses on the research ***methods*** section identifying key components of the study. What was the population? What kind of study was performed? What was measured and was this appropriate? Why is the conclusion different from clinical experience? Is the study internally valid? What are the potential sources and effects of bias?

What Do the Numbers Mean?

10:15–11:00 AM

Crystal L Dunlevy EdD RRT
Georgia State University
Atlanta, Georgia

Examines the research ***results*** section identifying the method of analysis and key results. Are the data presented appropriately in graphs, tables, or other form? Are there significant differences in the treatment groups? Are the data complete? Are they relevant? Are they meaningful?

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1998 Call for Abstracts

RESPIRATORY CARE • OPEN FORUM

The American Association for Respiratory Care and its science journal, RESPIRATORY CARE, invite submission of brief abstracts related to any aspect of cardiorespiratory care. The abstracts will be reviewed, and selected authors will be invited to present posters at the OPEN FORUM during the AARC International Respiratory Congress in Atlanta, Georgia, November 7–10, 1998. Accepted abstracts will be published in the October 1998 issue of RESPIRATORY CARE. Membership in the AARC is not required for participation. All accepted abstracts are automatically considered for ARCF research grants.

SPECIFICATIONS—READ CAREFULLY!

An abstract may report **(1) an original study, (2) the evaluation of a method, device or protocol, or (3) a case or case series.** Topics may be aspects of adult acute care, continuing care/rehabilitation, perinatology/pediatrics, cardiopulmonary technology, or health care delivery. The abstract may have been presented previously at a local or regional—but not national—meeting and should not have been published previously in a national journal. The abstract is the only evidence by which the reviewers can decide whether the author should be invited to present a poster at the OPEN FORUM. Therefore, *the abstract must provide all important data, findings, and conclusions.* Give specific information. Do not write such general statements as "Results will be presented" or "Significance will be discussed."

Essential Content Elements

Original study. Abstract *must* include (1) Background: statement of research problem, question, or hypothesis; (2) Method: description of research design and conduct in sufficient detail to permit judgment of validity; (3) Results: statement of research findings with quantitative data and statistical analysis; (4) Conclusions: interpretation of the meaning of the results.

Method, device, or protocol evaluation. Abstract *must* include (1) Background: identification of the method, device, or protocol and its intended function; (2) Method: description of the evaluation in sufficient detail to permit judgment of its objectivity and validity; (3) Results: findings of the evaluation; (4) Experience: summary of the author's practical experience or a lack of experience; (5) Conclusions: interpretation of the evaluation and experience. Cost comparisons should be included where possible and appropriate.

Case report. Abstract *must* report a case that is uncommon or of exceptional educational value and must include (1) Introduction: Relevant basic information important to understanding the case. (2) Case Summary: Patient data and response, details of interventions. (3) Discussion: Content should reflect results of literature review. The author(s) should have been actively involved in the case and a case-managing physician must be a co-author or must approve the report.

Abstract Format and Typing Instructions

Accepted abstracts will be photographed and reduced by 40%; therefore, the size of the original text should be *at least* 10 points. A font like Helvetica or Geneva makes the clearest reproduction. The first line of the abstract should be the title in all capital letters. Title should explain content. Follow title with names of all authors (including credentials), institution(s), and location; underline presenter's name. Type or electronically print the abstract *single spaced in a single paragraph in the space provided on the abstract blank.* Insert only one letter space between sentences. Text submission on diskette is encouraged but must be accompanied by a hard copy. Identifiers will be masked (blinded) for review. Data may be submitted in table form, *and simple figures may be included provided they fit within the space allotted.* No figures, illustrations, or tables are to be attached to the abstract form. Provide all author information requested. A clear photocopy of the abstract form may be used. Standard abbreviations may be employed without explanation; new or infrequently used abbreviations should be spelled out on first use. Any recurring phrase or expression may be abbreviated, if it is first explained. Check the abstract for (1) errors in spelling, grammar, facts, and figures; (2) clarity of language; and (3) conformance to these specifications. An abstract not prepared as requested may not be reviewed. Questions about abstract preparation may be telephoned to the editorial staff of RESPIRATORY CARE at (972) 406-4667.

Deadline Allowing Revision

Authors may choose to submit abstracts early. Abstracts postmarked by February 16, 1998 will be reviewed and the authors notified *by letter only* to be mailed by March 20, 1998. Rejected abstracts will be accompanied by a written critique that should, in many cases, enable authors to revise their abstracts and resubmit them by the final deadline (May 4, 1998).

Final Deadline

The mandatory Final Deadline is May 4, 1998 (postmark). Authors will be notified of acceptance or rejection *by letter only*. These letters will be mailed by July 20, 1998.

Mailing Instructions

Mail (Do not fax!) 2 clear copies of the completed abstract form, diskette (if possible), and a stamped, self-addressed postcard (for notice of receipt) to:

RESPIRATORY CARE OPEN FORUM
11030 Ables Lane
Dallas TX 75229-4593

1998 RESPIRATORY CARE OPEN FORUM

Abstract Form

1. Title must be in all upper case (capital) letters, authors' full names and text in upper and lower case.
2. Follow title with all authors' names including credentials (underline presenter's name), institution, and location.
3. Do not justify (ie, leave a 'ragged' right margin).
4. **Do not use type size less than 10 points.**
5. All text, tables, and figures must fit into the rectangle shown.
6. Submit 2 clean copies. This form may be photocopied if multiple abstracts are to be submitted.

Mail original &
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(along with postage-
paid postcard) to

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OPEN FORUM
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Early deadline is
February 16, 1998
(postmark)

Final deadline is
May 4, 1998
(postmark)

18.8 cm or 7.4"

13.9 cm or 5.5"

Presenter

Name & Credentials

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Corresponding Author If Different from Presenter

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American Association for Respiratory Care

Membership Application

Please read the eligibility requirements for each of the classifications in the right-hand column, then complete the applicable section. All information requested below must be provided, except where indicated as optional. See other side for more information and fee schedule. Please sign and date application on reverse side and type or print clearly. Processing of application takes approximately 15 days.

- ☐ Active
- Associate
  - ☐ Foreign
  - ☐ Physician
  - ☐ Industrial
- ☐ Special
- ☐ Student

Last Name ______________________________

First Name ______________________________

Social Security No. ______________________________

Home Address ______________________________

City ______________________________

State ____________ Zip ___ ___ ___ ___ ___ - ___ ___ ___ ___

Phone No. (______) ______________________________

Primary Job Responsibility (check one only)

- ☐ Technical Director
- ☐ Assistant Technical Director
- ☐ Pulmonary Function Specialist
- ☐ Instructor/Educator
- ☐ Supervisor
- ☐ Staff Therapist
- ☐ Staff Technician
- ☐ Rehabilitation/Home Care
- ☐ Medical Director
- ☐ Sales
- ☐ Student
- ☐ Other, specify ______________________________

Type of Business

- ☐ Hospital
- ☐ Skilled Nursing Facility
- ☐ DME/HME
- ☐ Home Health Agency
- ☐ Educational Institution
- ☐ Manufacturer or supplier
- ☐ Other, specify ______________________________

Date of Birth (optional) ____________ Sex (optional) ____________

U.S. Citizen? _____ Yes _____ No

Have you ever been a member of the AARC? ____________________

If so, when? From ____________________ to ____________________

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FOR ACTIVE MEMBER

An individual is eligible if he/she lives in the U.S. or its territories or was an Active Member prior to moving outside its borders or territories, and meets ONE of the following criteria (1) is legally credentialed as a respiratory care professional if employed in a state that mandates such, OR (2) is a graduate of an accredited educational program in respiratory care, OR (3) holds a credential issued by the NBRC An individual who is an AARC Active Member in good standing on December 8, 1994, will continue as such provided his/her membership remains in good standing

PLEASE USE THE ADDRESS OF THE LOCATION WHERE YOU PERFORM YOUR JOB, NOT THE CORPORATE HEADQUARTERS IF IT IS LOCATED ELSEWHERE

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City ______________________________

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Phone No. (______) ______________________________

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FOR ASSOCIATE OR SPECIAL MEMBER

Individuals who hold a position related to respiratory care but do not meet the requirements of Active Member shall be Associate Members. They have all the rights and benefits of the Association except to hold office, vote, or serve as chair of a standing committee. The following subclasses of Associate Membership are available Foreign, Physician, and Industrial (individuals whose primary occupation is directly or indirectly devoted to the manufacture, sale, or distribution of respiratory care equipment or supplies) Special Members are those not working in a respiratory care-related field

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Phone No. (______) ______________________________

FOR STUDENT MEMBER

Individuals will be classified as Student Members if they meet all the requirements for Associate Membership and are enrolled in an educational program in respiratory care accredited by, or in the process of seeking accreditation from, an AARC-recognized agency

SPECIAL NOTICE — Student Members do not receive Continuing Respiratory Care Education (CRCE) transcripts. Upon completion of your respiratory care education, continuing education credits may be pursued upon your reclassification to Active or Associate Member

School/RC Program ______________________________

Address ______________________________

City ______________________________

State ____________ Zip ___ ___ ___ ___ ___ - ___ ___ ___ ___

Phone No. (______) ______________________________

Length of program

- ☐ 1 year
- ☐ 2 years
- ☐ 4 years
- ☐ Other, specify ____________

Expected Date of Graduation (REQUIRED INFORMATION)

Month ________ Year ________

AARC

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American Association for Respiratory Care Membership Application

Demographic Questions

We request that you answer these questions in order to help us design services and programs to meet your needs.

Check the Highest Degree Earned

- ☐ High School
- ☐ RC Graduate Technician
- ☐ Associate Degree
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctorate Degree

Number of Years in Respiratory Care

- ☐ 0-2 years
- ☐ 3-5 years
- ☐ 6-10 years
- ☐ 11-15 Years
- ☐ 16 years or more

Job Status

- ☐ Full Time
- ☐ Part Time

Credentials

- ☐ RRT
- ☐ CRTT
- ☐ Physician
- ☐ CRNA
- ☐ RN
- ☐ LVN/LPN
- ☐ CPFT
- ☐ RPFT
- ☐ Perinatal/Pediatric

Salary

- ☐ Less than $10,000
- ☐ $10,001-$20,000
- ☐ $20,001-$30,000
- ☐ $30,001-$40,000
- ☐ $40,000 or more

PLEASE SIGN

I hereby apply for membership in the American Association for Respiratory Care and have enclosed my dues. If approved for membership in the AARC, I will abide by its bylaws and professional code of ethics. I authorize investigation of all statements contained herein and understand that misrepresentations or omissions of facts called for is cause for rejection or expulsion.

A yearly subscription to Respiratory Care journal and *AARC Times* magazine includes an allocation of $6.50 from my dues for each of these publications.

NOTE: Contributions or gifts to the AARC are not tax deductible as charitable contributions for income tax purposes. However, they may be tax deductible as ordinary and necessary business expenses subject to restrictions imposed as a result of association lobbying activities. The AARC estimates that the nondeductible portion of your dues — the portion which is allocable to lobbying — is 26%.

Signature ______________________________

Date ______________________________

Membership Fees

Payment must accompany your application to the AARC. Fees are for 12 months. (NOTE: Renewal fees are $65.00 Active, Associate-Industrial or Associate-Physician, or Special status; $80.00 for Associate-Foreign status; and $35.00 for Student status).

☐ Active	$77.50
☐ Associate (Industrial or Physician)	$77.50
☐ Associate (Foreign)	$92.50
☐ Special	$77.50
☐ Student	$35.00
TOTAL	$__________

Specialty Sections

Established to recognize the specialty areas of respiratory care, these sections publish a newsletter four times a year that focuses on issues of specific concern to that specialty. The sections also design the specialty programming at the national AARC meetings.

☐ Adult Acute Care Section	$5.00
☐ Education Section	$10.00
☐ Perinatal-Pediatric Section	$5.00
☐ Diagnostics Section	$5.00
☐ Continuing Care-Rehabilitation Section	$5.00
☐ Management Section	$10.00
☐ Transport Section	$5.00
☐ Home Care Section	$5.00
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TOTAL	$__________

GRAND TOTAL = Membership Fee plus optional sections $__________

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RESPIRATORY CARE

Manuscript Preparation Guide

General Information

RESPIRATORY CARE welcomes original manuscripts related to the science and technology of respiratory care and prepared according to these Instructions and the *Uniform Requirements for Manuscripts Submitted to Biomedical Journals* [Respir Care 1997; 42(6):623-634]. Manuscripts are blinded and reviewed by professionals who are experts in their fields. Authors are responsible for all aspects of the manuscript and receive galleys to proofread before publication. Each accepted manuscript is copyedited so that its message is clear and it conforms to the Journal's style. Published papers are copyrighted by Daedalus Inc and may not be published elsewhere without permission.

Editorial consultation is available at any stage of planning or writing. On request, specific guidance is provided for all publication categories. To receive these Instructions and related materials, write to RESPIRATORY CARE, 600 Ninth Avenue, Suite 702, Seattle WA 98104, call (206) 223-0558, or fax (206) 223-0563.

Publication Categories & Structure

Research Article: A report of an original investigation (a study). It includes a Title Page, Abstract, Introduction, Methods, Results, Discussion, Conclusions, Product Sources, Acknowledgments, References, Tables, Appendices, Figures, and Figure Captions.

Evaluation of Device/Method/Technique: A description and evaluation of an old or new device, method, technique, or modification. It has a Title Page, Abstract, Introduction, Description of Device/Method/Technique, Evaluation Methods, Evaluation Results, Discussion, Conclusions, Product Sources, Acknowledgments, References, Tables, Appendices, Figures, and Figure Captions. Comparative cost data should be included wherever possible.

Case Report: A report of a clinical case that is uncommon, or was managed in a new way, or is exceptionally instructive. All authors must be associated with the case. A case-managing physician must either be an author or furnish a letter approving the manuscript. Its components are Title Page, Abstract, Introduction, Case Summary, Discussion, References, Tables, Figures, and Figure Captions.

Review Article: A comprehensive, critical review of the literature and state-of-the-art summary of a pertinent topic that has been the subject of at least 40 published research articles. Title Page, Outline, Introduction, Review of the Literature, Summary, Acknowledgments, References, Tables, Appendices, and Figures and Captions may be included.

Overview: A critical review of a pertinent topic that has fewer than 40 published research articles.

Update: A report of subsequent developments in a topic that has been critically reviewed in this Journal or elsewhere.

Point-of-View Paper: A paper expressing personal but substantiated opinions on a pertinent topic. Title Page, Text, References, Tables, and Illustrations may be included.

Special Article: A pertinent paper not fitting one of the foregoing categories may be acceptable as a Special Article. Consult with the Editor before writing or submitting such a paper.

Editorial: A paper drawing attention to a pertinent concern; it may present an opposing opinion, clarify a position, or bring a problem into focus.

Letter: A signed communication, marked "For publication," about prior publications in this Journal or about other pertinent topics. Tables and illustrations may be included.

Blood Gas Corner: A brief, instructive case report involving blood gas values—with Questions, Answers, and Discussion.

Drug Capsule: A mini-review paper about a drug or class of drugs that includes discussions of pharmacology, pharmacokinetics, and pharmacotherapy.

Graphics Corner: A brief case report incorporating waveforms for monitoring or diagnosis—with Questions, Answers, and Discussion.

Kittredge's Corner: A brief description of the operation of respiratory care equipment—with information from manufacturers and editorial comments and suggestions.

PFT Corner: Like Blood Gas Corner, but involving pulmonary function tests.

Cardiorespiratory Interactions. A case report demonstrating the interaction between the cardiovascular and respiratory systems. It should be a patient-care scenario; however, the case—the central theme—is the systems interaction. CRI is characterized by figures, equations, and a glossary. See the March 1996 Issue of RESPIRATORY CARE for more detail.

Test Your Radiologic Skill: Like Blood Gas Corner, but involving pulmonary medicine radiography and including one or more radiographs; may involve imaging techniques other than conventional chest radiography.

Review of Book, Film, Tape, or Software: A balanced, critical review of a recent release.

Preparing the Manuscript

Print on one side of white bond paper, 8.5 in. x 11 in. (216 x 279 mm) with margins of at least 1 in. (25 mm) on all sides of the page. Use ***double-spacing*** throughout the ***entire*** manuscript. Use a standard font (eg, Times, Helvetica, or Courier) at least 10 points in size, and do not use italics except for special emphasis. Number all pages in upper-right corners. Indent paragraphs 5 spaces. Do ***not justify*. Do *not* put authors' names, institutional affiliations or allusions to institutional affiliations in the text, or other identification anywhere except on the title page.** Repeat title only (no authors) on the abstract page. Begin each of the following on a new page: Title Page, Abstract, Text, Product Sources List, Acknowledgments, References, each Table, and each Appendix. Use standard English in the first person and active voice.

Center main section headings on the page and type them in capital and small letters (eg, Introduction, Methods, Results, Discussion). Begin subheadings at the left margin and type them in capital and small letters (eg, Patients, Equipment, Statistical Analysis).

References. Cite only published works as references. Manuscripts accepted but not yet published may be cited as references: designate the accepting journal, followed by (in press), and provide 3 copies of the in-press article for reviewer inspection. Cite references in the text with superscript numerals. Assign numbers in the order that references are first cited. On the reference page, list the cited works in numerical order. Follow the Journal's style for references. Abbreviate journal names as in *Index Medicus*. List all authors.

Article in a journal carrying pagination throughout volume:

> Rau JL, Harwood RJ. Comparison of nebulizer delivery methods through a neonatal endotracheal tube: a bench study. Respir Care 1992;37(11):1233-1240.

Article in a publication that numbers each issue beginning with Page 1:

> Bunch D. Establishing a national database for home care. AARC Times 1991;15(Mar):61,62,64

Corporate author journal article:

> American Association for Respiratory Care. Criteria for establishing units for chronic ventilator-dependent patients in hospitals. Respir Care 1988;33(11):1044-1046.

Article in journal supplement: (Journals differ in their methods of numbering and identifying supplements. Supply sufficient information to promote retrieval.)

> Reynolds HY. Idiopathic interstitial pulmonary fibrosis. Chest 1986; 89(3 Suppl):139S-143S.

Abstract in journal: (Abstracts citations are to be avoided. Those more than 3 years old should not be cited.)

> Stevens DP. Scavenging ribavirin from an oxygen hood to reduce environmental exposure (abstract). Respir Care 1990;35(11): 1087-1088.

Editorial in journal:

> Enright P. Can we relax during spirometry? (editorial). Am Rev Respir Dis 1993;148(2):274.

Editorial with no author given:

> Negative-pressure ventilation for chronic obstructive pulmonary disease (editorial). Lancet 1992;340(8833):1440-1441.

Letter in journal:

> Aelony Y. Ethnic norms for pulmonary function tests (letter). Chest 1991;99(4):1051.

Paper accepted but not yet published:

> Hess D. New therapies for asthma. Respir Care (year, in press).

Personal author book: (For any book, specific pages should be cited whenever possible.)

> DeRemee RA. Clinical profiles of diffuse interstitial pulmonary disease. New York: Futura; 1990. p. 76-85.

Corporate author book:

> American Medical Association Department of Drugs. AMA drug evaluations, 3rd ed. Littleton CO: Publishing Sciences Group; 1977.

Chapter in book with editor(s):

> Pierce AK. Acute respiratory failure. In: Guenter CA, Welch MH, editors. Pulmonary medicine. Philadelphia: JB Lippincott; 1977:26-42.

Tables. Use consecutively numbered tables to display information. Start each table on a separate page. Number and title the table and give each column a brief heading. Place explanations in footnotes, including all nonstandard abbreviations and symbols. Key the footnotes with conventional designations (*, †, ‡, §, ||, ¶, **, ††) in consistent order, placing them superscript in the table body. Do not use horizontal or vertical rules or borders. Do not submit tables as photographs, reduced in size, or on oversize paper. Use the same typeface as in the text.

Illustrations. Graphs, line drawings, photographs, and radiographs are figures. Use only illustrations that clarify and augment the text. Number them consecutively as Fig. 1, Fig. 2, and so forth according to the order by which they are mentioned in the text. Be sure all figures are cited. If any figure was previously published, include copyright holder's written permission to reproduce. Figures for publication must be of professional quality. Data for the original graphs should be available to the Editor upon request. If color is essential, consult the Editor for more information. In reports of animal experiments, use schematic drawings, not photographs. A letter of consent must accompany any photograph of a person. Do not place titles and detailed explanations on figures; put this information in figure captions. If possible, submit radiographs as prints and full-size copies of film.

Drugs. Identify precisely all drugs and chemicals used, giving generic names, doses, and routes of administration. If desired, brand names may be given in parentheses after generic names. Drugs should be listed on the product-sources page.

Commercial Products. In parentheses in the text, identify any commercial product (including model number if applicable) the first time it is mentioned, giving the manufacturer's name, city, and state or country. If four or more products are mentioned, do not list any manufacturers in the text; instead, list them on a Product Sources page at the end of the text, before the References. Provide model numbers when available and manufacturer's suggested price, if the study has cost implications.

Ethics. When reporting experiments on human subjects, indicate that procedures were conducted in accordance with the ethical standards of the *World Medical Association Declaration of Helsinki* [Respir Care 1997:42(6):635-636] or of the institution's committee on human experimentation. State that informed consent was obtained. Do not use patient's names, initials, or hospital numbers in text or illustrations. When reporting experiments on animals, indicate that the institution's policy, a national guideline, or a law on the care and use of laboratory animals was followed.

Statistics. Identify the statistical tests used in analyzing the data, and give the prospectively determined level of significance in the Methods section. Report actual p values in Results. Cite only textbook and published article references to support choices of tests. Identify any general-use or commercial computer programs used, naming manufacturers and their locations. These should be listed on the product-sources page.

Units of Measurement. Express measurements of length, height, weight, and volume in metric units appropriately abbreviated; temperatures in degrees Celsius; and blood pressures in millimeters of mercury (mm Hg). Report hematologic and clinical-chemistry measurements in conventional metric and in SI (*Systémé Internationale*) units. Show gas pressures (including blood gas tensions) in torr. List SI equivalent values, when possible, in brackets following non-SI values—for example, "PEEP, 10 cm H_2O [0.981 kPa]." For conversion to SI, see RESPIRATORY CARE 1988;33(10):861-873 (Oct 1988), 1989;34(2):145 (Feb 1989), and 1997;42(6):639-640 (June 1997).

Conflict of Interest. Authors are asked to disclose any liaison or financial arrangement they have with a manufacturer or distributor whose product is part of the submitted manuscript or with the manufacturer or distributor of a competing product. (Such arrangements do not disqualify a paper from consideration and are not disclosed to reviewers.) A statement to this effect is included on the cover-letter page. (Reviewers are screened for possible conflict of interest.)

Abbreviations and Symbols. Use standard abbreviations and symbols. Avoid creating new abbreviations. Avoid all abbreviations in the title and unusual abbreviations in the abstract. Use an abbreviation only if the term occurs several times in the paper. Write out the full term the first time it appears, followed by the abbreviation in parentheses. Thereafter, employ the abbreviation alone. Never use an abbreviation without defining it. Standard units of measurement can be abbreviated without explanation (eg, 10 L/min, 15 torr, 2.3 kPa).

Please use the following forms: cm H_2O (not cmH2O), f (not bpm), L (not l), L/min (not LPM, l/min, or lpm), mL (not ml), mm Hg (not mmHg), pH (not Ph or PH), $p > 0.001$ (not p>0.001), s (not sec), S_{pO_2} (pulse-oximetry saturation). See RESPIRATORY CARE: Standard Abbreviations and Symbols [Respir Care 1997;42(6):637-642].

Submitting the Manuscript

Mail three copies [1 copy with author(s) name(s), affiliation(s), 2 copies without name(s) and affiliation(s) for reviewers] of the manuscript, figures, and 1 diskette, and the Cover Letter & Checklist to RESPIRATORY CARE, 600 Ninth Avenue, Suite 702, Seattle WA 98104. Do not fax manuscripts. Protect figures with cardboard. Keep a copy of the manuscript and figures. Receipt of your manuscript will be acknowledged.

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MEDWATCH

THE FDA MEDICAL PRODUCTS REPORTING PROGRAM

For VOLUNTARY reporting
by health professionals of adverse
events and product problems

Page ___ of ___

Form Approved: OMB No 0910-0291 Expires 4/30/
See OMB statement on revers

FDA Use Only (Resp Care)

Triage unit
sequence #

A. Patient information

1 Patient identifier
In confidence

2 Age at time of event: ______
or
Date of birth:

3 Sex
☐ female
☐ male

4 Weight
____ lbs
or
____ kgs

B. Adverse event or product problem

1. ☐ Adverse event and/or ☐ Product problem (e.g., defects/malfunctions)

2. Outcomes attributed to adverse event (check all that apply)
- ☐ death ______ (mo/day/yr)
- ☐ life-threatening
- ☐ hospitalization – initial or prolonged
- ☐ disability
- ☐ congenital anomaly
- ☐ required intervention to prevent permanent impairment/damage
- ☐ other: ______

3. Date of event (mo/day/yr)

4 Date of this report (mo/day/yr)

5. Describe event or problem

6. Relevant tests/laboratory data, including dates

7 Other relevant history, including preexisting medical conditions (e.g., allergies, race, pregnancy, smoking and alcohol use, hepatic/renal dysfunction, etc.)

C. Suspect medication(s)

1 Name (give labeled strength & mfr/labeler, if known)
#1
#2

2. Dose, frequency & route used
#1
#2

3 Therapy dates (if unknown, give duration) from/to (or best estimate)
#1
#2

4 Diagnosis for use (indication)
#1
#2

5 Event abated after use stopped or dose reduced
#1 ☐ yes ☐ no ☐ doesn't apply
#2 ☐ yes ☐ no ☐ doesn't apply

6. Lot # (if known)
#1
#2

7 Exp. date (if known)
#1
#2

8 Event reappeared after reintroduction
#1 ☐ yes ☐ no ☐ doesn't apply
#2 ☐ yes ☐ no ☐ doesn't apply

9 NDC # (for product problems only)
– –

10 Concomitant medical products and therapy dates (exclude treatment of event)

D. Suspect medical device

1 Brand name

2 Type of device

3 Manufacturer name & address

4 Operator of device
- ☐ health professional
- ☐ lay user/patient
- ☐ other:

5. Expiration date (mo/day/yr)

6.
model #
catalog #
serial #
lot #
other #

7 If implanted, give date (mo/day/yr)

8. If explanted, give date (mo/day/yr)

9 Device available for evaluation? (Do not send to FDA)
☐ yes ☐ no ☐ returned to manufacturer on ______ (mo/day/yr)

10 Concomitant medical products and therapy dates (exclude treatment of event)

E. Reporter (see confidentiality section on back)

1 Name & address

phone #

2 Health professional?
☐ yes ☐ no

3. Occupation

4 Also reported to
- ☐ manufacturer
- ☐ user facility
- ☐ distributor

5. If you do NOT want your identity disclosed to the manufacturer, place an " X " in this box. ☐

FDA

Mail to: MEDWATCH
5600 Fishers Lane
Rockville, MD 20852-9787

or FAX to:
1-800-FDA-0178

FDA Form 3500 1/96)

Submission of a report does not constitute an admission that medical personnel or the product caused or contributed to the eve

ADVICE ABOUT VOLUNTARY REPORTING

Report experiences with:

- medications (drugs or biologics)
- medical devices (including in-vitro diagnostics)
- special nutritional products (dietary supplements, medical foods, infant formulas)
- other products regulated by FDA

Report SERIOUS adverse events. An event is serious when the patient outcome is:

- death
- life-threatening (real risk of dying)
- hospitalization (initial or prolonged)
- disability (significant, persistent or permanent)
- congenital anomaly
- required intervention to prevent permanent impairment or damage

Report even if:

- you're not certain the product caused the event
- you don't have all the details

Report product problems – quality, performance or safety concerns such as:

- suspected contamination
- questionable stability
- defective components
- poor packaging or labeling
- therapeutic failures

How to report:

- just fill in the sections that apply to your report
- use section C for all products except medical devices
- attach additional blank pages if needed
- use a separate form for each patient
- report either to FDA or the manufacturer (or both)

Important numbers:

• 1-800-FDA-0178	to FAX report
• 1-800-FDA-7737	to report by modem
• 1-800-FDA-1088	to report by phone or for more information
• 1-800-822-7967	for a VAERS form for vaccines

If your report involves a serious adverse event with a device and it occurred in a facility outside a doctor's office, that facility may be legally required to report to FDA and/or the manufacturer. Please notify the person in that facility who would handle such reporting.

Confidentiality: The patient's identity is held in strict confidence by FDA and protected to the fullest extent of the law. The reporter's identity, including the identity of a self-reporter, may be shared with the manufacturer unless requested otherwise. However, FDA will not disclose the reporter's identity in response to a request from the public, pursuant to the Freedom of Information Act.

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Calendar of Events

AARC & AFFILIATES

December 1—Live Telephone Question-and-Answer Session

View "Marketing Services to Managed Care Organizations: Not Just for Managers," Part 8 of the AARC's 1997 "Professor's Rounds," and participate in a live telephone question-and-answer session from 12:30 to 1 PM Eastern Time

CRCE: 1 CRCE credit hour

Contact: The AARC at (972) 243-2272 to receive the videotape and to register.

December 6–9—AARC 43rd International Respiratory Congress

The Congress will be held in New Orleans, Louisiana.

Contact: The convention office at (972) 243-2272 or see the advance program in the September issue of *AARC Times*.

February 5–8, 1998—AARC & Clinical Laboratory Management Association (CLMA)

The Second Annual Congress on Integrated Health Care Management at the Dallas Lakes Hilton, Dallas, Texas. Last year's Congress was highlighted in the June issue of *AARC Times*.

Contact: CLMA at (610) 995-9580 or (202) 543-7971.

OTHER MEETINGS

October 16–18, 1997— Austrian Society of Tuberculosis and Pulmonary Diseases

Clinical Respiratory Physiology Workshop at the Innsbruck/Austria Kongresshaus, Innsbruck, Austria.

Contact: Dr M Kneussl, Medizinische Ausstellungs- und Werbegesellschaft, Freyung 6, A-1010 Vienna, Austria, phone (+43/1) 536 63.0, fax (+43/1) 535 60 16, or e-mail maw@media.co.at.

MARK YOUR CALENDARS

1998
AARC International
Respiratory Congress

November 7-10, 1998
Atlanta, Georgia

AARC
Summer Forum

November 7-10, 1998
Atlanta, Georgia

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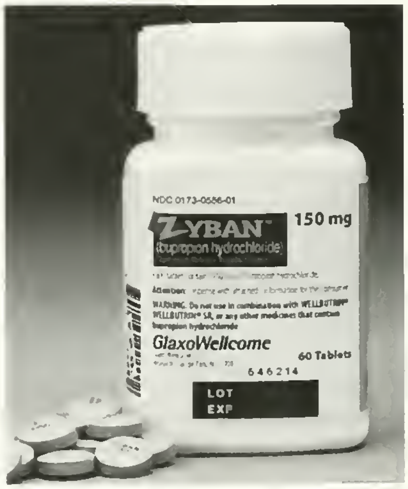
News releases about new products and services will be considered for publication in this section. There is no charge for these listings. Send descriptive release and glossy black and white photographs to RESPIRATORY CARE Journal, New Products and Services Dept, 11030 Ables Lane, Dallas TX 75229-4593. The Reader Service Card immediately follows the authors & advertisers index at the back of the Journal.

MEDICAL PRESS CATALOG. Medical Arts Press releases it 1997 fall and winter catalog of office essentials for the medical professions. The catalog features more than 200 pages of products including insurance forms, filing supplies, envelopes, labels, and stationery. A free copy is available. Circle Reader Service Number 160.

ELECTROCARDIOGRAM RECORDER. Oxford Instruments launches the Medilog® FD4 Ambulatory Electrocardiogram (ECG) Recorder. The Medilog uses flash card technology for optimum data storage and provides on-line updates via a cable link from any Oxford Excel, Optima, or Prima Holter system. In addition, the company claims that the Medilog can record on up to 3 channels and up to 24 hours of continuous data. The reusable plug-in flash card can be used with the Holter monitor to minimize loss of data, retain patient details and data indefinitely, and speed up recorder turnaround. The recorder is lightweight, features low-power consumption, automatic gain adjustment and calibration, 3-5-7 lead variants, patient event button, high-impact case construction, lockable lid, and LCD display. Circle Reader Service Number 161 for details.



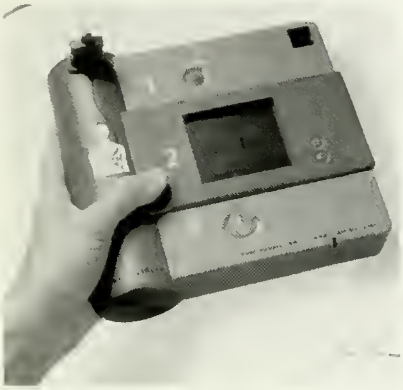
SMOKING-CESSATION MEDICATION. Zyban™ (bupropion hydrochloride) Sustained-Release Tablets are offered by GlaxoWellcome Inc. According to the manufacturer, the nicotine-free prescription medication designed as an aid to help people quit smoking, is approved by the U. S. Food and Drug Administration. Furthermore, the tablet works differently than nicotine replacement therapy and is thought to work on the biology of nicotine addiction. The medicine also includes a personalized patient support program called the Zyban Advantage Plan™, available to patients at no additional charge. For more information about the medication, indications, contraindications, and side effects, circle Reader Service 162.

ASTHMA PACK UPDATE. HealthScan Products updates its AsthmaPACK with the new OptiChamber Valved Holding Chamber, the Personal Best® Peak Flow Meter, a videotape, a self-help booklet, and a vinyl carrying case. Select Reader Service Number 163 for more details about AsthmaPACK II.

TRAINING SYSTEM. Cinecraft Health and Safety Systems offers a new training product, Staff Training and Tracking Technology. (STATT). The program assists health care professionals in meeting Joint Commission for the Accreditation of Healthcare Organizations and Occupational Safety and Health Administration requirements, company literature claims. The program is computer-based and uses an interactive CD-ROM system. The titles include: *Basic Infection Control, Back Safety in the Health Care Environment, and Protecting Yourself from Bloodborne Pathogens.* The system also includes a tracking program that records each learner's data and creates reports for the administrator. Circle Reader Service Number 164 for details.

CYSTIC FIBROSIS (CF) NEWSLETTER. Ortho-McNeil Pharmaceutical publishes a quarterly newsletter, *CF News,* for adults with cystic fibrosis. According to a company press release, the newsletter provides information about the disease, staying healthy, transplantation, finances, education and career planning, and lifestyle topics written by adults living with the once childhood disease. For details about the free subscription, select Reader Service Number 165.

AUTOMATIC EXTERNAL DEFIBRILLATOR. Schiller America introduces the ForeRunner automatic external defibrillator (AED). According to a company press release, the ForeRunner is designed to improve the survival rate from sudden cardiac arrest and can be used by basic-cardiopulmonary-resuscitation-trained individuals. The release also says that the ForeRunner's computerized algorithm automatically analyzes the patient's heart rhythm to determine if a shock is necessary, activates the shock button, and advises the operator that the shock is needed when a life-threatening heart rhythm is identified. The shock is delivered in a biphasic waveform. The device is small and lightweight and uses automatic self-test technologies and a long-life disposable battery cartridge. For details about the AED available in 3 models, circle Reader Service 166.



FILTER. Gibeck introduces the Humid-Vent Filter Compact. According to the company, the filter is a heat and moisture exchanger, bacterial and viral filter that meets International Standards Organization 9360 for moisture output, dead space, and flow resistance. The filter is available in an angled version and is small, efficient, and safe at high tidal volumes. To contact Gibeck for details, circle Reader Service 167.

Tax Software. ATX Forms Inc claims that its Tax$olver for Business program includes virtually every type of business tax return that will be needed by small business owners. According to a company press release, Tax$olver not only permits users to keep expenses to a minimum, but it also permits them to view a wide range tax options. The program is available on compact disk only and requires a 486-processor personal computer with a recommended 8 MB of RAM. It is designed to run on Windows 3.1, 95, and NT. For more information about computer requirements, circle Reader Service Number 168.

Inhaled Bronchodilator. GlaxoWellcome Inc announces U.S. Food and Drug Administration clearance for marketing SEREVENT® DISKUS® (salmeterol xinafoate inhalation powder), a new delivery device that helps ensure consistent medication delivery for asthma patients. The new device has a built-in dose counter that highlights the last 5 doses in red—the number of remaining doses, according to GlaxoWellcome literature. In order to take the medication, the patient rotates the delivery device which automatically prepares one unit dose to be released. For a complete list of indications, contraindications, and side effects, circle Reader Service Number 169.

Infant Apnea Monitor. Nellcor Puritan Bennett Inc has received U.S. Food and Drug Administration clearance to market the new Ami™ infant apnea monitor. The manufacturer reports that Ami is designed for monitoring infants who exhibit potential apneic events. In addition, Nellcor Puritan Bennett says that the monitor is durable, small, portable, and operable with AC or battery power. Other options are a built-in modem for remote data retrieval and transfer and auxiliary channels for measuring saturation, pulse rate, body position, air flow, and pH. For details about the monitor's complete software package, circle Reader Service Number 170.

Capnograph. BCI International announces the introduction of the second monitor in their Clarity™ Series, the Capnocheck® Plus. According to the manufacturer, this stand-alone, bedside or transportable capnograph incorporates side-stream technology for applications on both intubated and nonintubated patients. In addition, the capnograph can store and recall data either via on-screen trends, a printer, or a personal computer. For details about the Capnocheck, circle Reader Service Number 171.

Smoking-Cessation Aid. ProGenesis offers its drug-free stop-smoking aid, the HabitEX® habit control system, for $265. The system includes the custom-designed, programmable Triggered Suggestion® wristwatch and a 20-minute compact-disc program. The manufacturer reports that a recent medically supervised study funded by the national Institutes of Health proved that individuals using the HabitEX system had an easier time not smoking and reduced their smoking behavior. To receive more information about the system, circle Reader Service Number 172.

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Valley Children's Hospital	1070	Circle Reader Service No. 96	See ad

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6. ☐ Distributor

II. Department
A. ☐ Respiratory Care
B. ☐ Cardiopulmonary
C. ☐ Subacute Care
D. ☐ Home Care

III. Specialty
1. ☐ Clinician
2. ☐ Perinatal/Pediatrics
3. ☐ Critical Care
4. ☐ Research
5. ☐ Subacute Care
6. ☐ Diagnostics/ Pulmonary Function
7. ☐ Management
8. ☐ Home Care
9. ☐ Rehabilitation
10. ☐ Education

IV. Position
A. ☐ Department Head
B. ☐ Chief Therapist
C. ☐ Supervisor
D. ☐ Staff Therapist/ Technician
E. ☐ Medical Director
F. ☐ Educator/Instructor
I. ☐ Sales
J. ☐ Other (please specify) ______________

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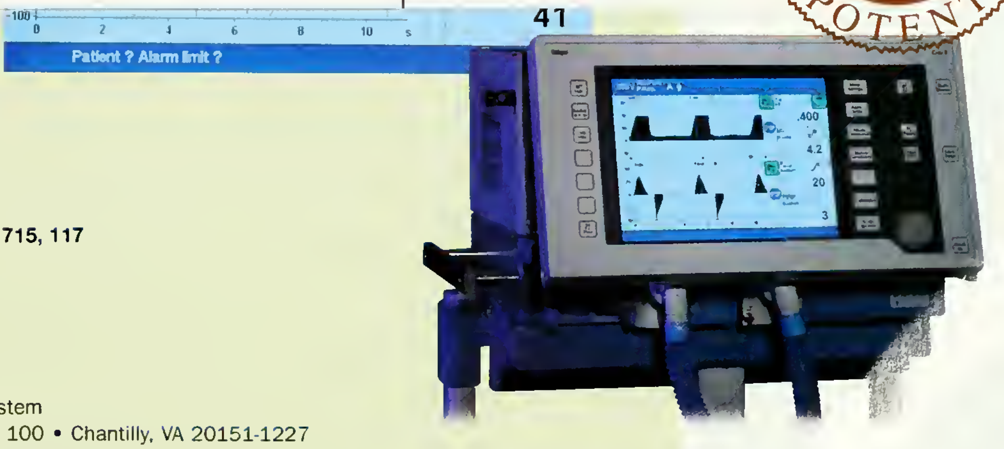

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BETWEEN PATIENT AND VENTILATOR

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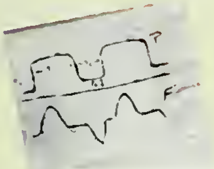

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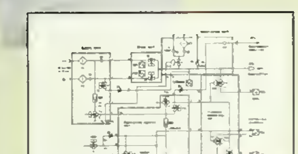

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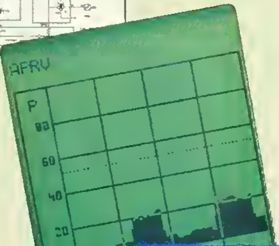

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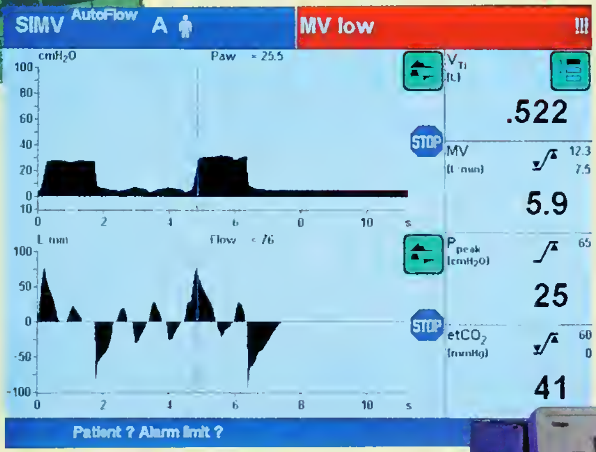

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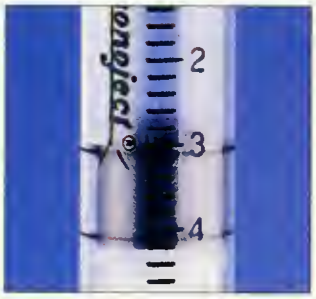

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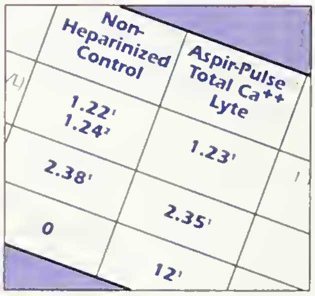

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